A-4 SKYHAWK VS NORTH VIETNAMESE AAA

North Vietnam 1964–72

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INTRODUCTION

At the Douglas Aircraft Company in 1952, chief designer Ed Heinemann and his team had straightforward objectives for their A4D-1 bomber. It had to be the smallest, lightest and fastest carrier-borne striker that could be built around a 1,800lb Mk 7 nuclear weapon. The US Navy was then using piston-engine strike aircraft in the Korean War, flying long missions and facing deadly Soviet-built anti-aircraft artillery (AAA). One of them, the excellent Douglas AD Skyraider, which Heinemann had designed to be lighter and less complex than rival types, flew similar missions against Soviet- and Chinese-built AAA in Vietnam 15 years later.

The US Navy also had faster fighters like the Grumman F9F Panther and McDonnell F2H Banshee powered by small uneconomical turbojet engines, but they lacked endurance and ordnance capacity. Heinemann sought to maximize the turbojet's benefits – its simplicity, light weight and development potential compared with piston engines – and combine them with the smallest possible airframe.

His other main objective was simplicity in design, commensurate with the mission requirements, and high subsonic cruise speeds. Heinemann noted that military aircraft procurement agencies, encouraged by manufacturers, were loading their new types with increasingly complex and costly equipment, particularly in the burgeoning new field of electronics. That led to steadily reduced performance, increased vulnerability to AAA and frequent cancellation. Heinemann's own TB2D Skypirate and SB2D Destroyer naval attack aircraft suffered that fate. He pointed out to the US Navy's Bureau of Aeronautics (BuAer) that for every pound weight of extra equipment added to an aircraft, its gross weight had to be increased by a factor of ten to preserve its range and performance. Based on a study for a supersonic interceptor, he analyzed and questioned the necessity of every aspect of the design, from the cable connectors to the rudder. Where they were considered essential Heinemann sought cheaper, lighter

alternatives. Although his interceptor was rejected, Heinemann was asked to apply his design principles to a lightweight attack aircraft instead – within two weeks.

The result of Heinemann's marathon day-and-night design effort was a small, delta-wing "hot rod" fitted with a Wright Aeronautical J65-W-2 (license-built British Armstrong Siddeley Sapphire) axial flow turbojet. The wingspan of 27.5ft was small enough to rule out wing-folding for aircraft carrier use. It weighed 12,000lbs, far below the US Navy estimate of 30,000lbs. BuAer officials felt that Heinemann's proposal was totally unrealistic but he pressed ahead, encouraged by the Chief of the BuAer, Rear Admiral Apollo Soucek. Designer R. G. Smith produced a three-view layout for the US Navy.

This immaculate VA-76 A4D-2 (BuNo 142784) was photographed bombed-up on board USS *Intrepid* (CVA-11) for simulated atomic bomb and CAS strikes during an exercise in the Mediterranean in late 1961. VA-76 was one of three Skyhawk-equipped units assigned to Carrier Air Group 6 at this time. (US Navy)

Amidst a generally skeptical response, Cdr John Brown, in charge of attack aircraft design and procurement at BuAer, was most enthusiastic. He asked for the jet's combat radius to be increased by 100 miles and its bombload to be doubled, increasing the overall weight to 14,300lbs. The project was approved as the Douglas A4D Skyhawk. with Ben Collins as project engineer. Unusually, the contract was awarded without the standard competitive submission process – a tribute to the US Navy's basic faith in the Douglas Aircraft Company and Heinemann's ability, as a self-taught engineer, to think adventurously and devise his own innovative solutions.

Heinemann's team achieved his objectives in designing a bomber that was about half the weight of its contemporaries. The A4D was constructed using around two-thirds of the parts needed for most 30,000lb aircraft of the time, its cost was $140,000 below the $1m target and its maintenance and overhaul times were around half those of existing service types. The A4D exceeded the US Navy's specified maximum speed by 100 knots and its small size yielded a radar signature that was only one percent of the specified figure – a vital factor for its intended attack role. Although it would never perform its intended nuclear strike mission, the A4D remained in production for 17 years and became the US Navy's primary attacker with conventional weapons.

By the time A4D-1s began to enter US Navy service in late 1956, North Vietnamese gunners were already gaining combat experience against French aircraft with the Soviet-supplied AAA weapons that they would use with such deadly effect against the Skyhawks that became the US Navy's main strike aircraft in operations in Southeast Asia. The ensuing battles in the 1960s became some of the hardest-fought and costliest encounters of the Vietnam War.

North Vietnam's AAA defenses were established on a relatively modest scale during the 1950s. However, by the end of 1963, with substantial new Soviet supplies, the force had expanded to 12 regiments equipped with 2,100 AAA weapons in its Anti-

The 7.92mm German-designed MG 34 machine gun was extensively used in North Vietnam, particularly against US helicopters. MG 34s in-theater came from a variety of sources, with some being ex-German stock captured by the Soviet Union and others having been manufactured in Czechoslovakia post-World War II. Several hundred more had been seized from the French during the colonial fighting of the 1950s. (Author's Collection)

Aircraft Artillery Branch, which was subordinate to the Anti-Aircraft Command. The Branch was divided into forces specializing in strategic area defense and forward-deployed anti-aircraft forces. In June 1964 the 234th Anti-Aircraft Regiment and the 23rd Battalion from Military Region 4 of the field forces were sent to Laos to support communist insurgents, and they claimed to have shot down six aircraft there. It was valuable experience which the Branch would soon use against US aircraft back home.

North Vietnam had massively increased its AAA strength by the beginning of Operation *Rolling Thunder* in March 1965, concentrating its guns around main towns, industrial sites, transportation hubs and bridges. At the same time, it prioritized the mobility of those resources, constructing up to four alternative battery sites around important potential targets and relying on the fact that even the heaviest guns (and eventually SA-2 surface-to-air missile batteries) could be towed to new locations and set up within hours. This capability also allowed the movement of AAA guns into Laos in 1965 when US attacks on the Ho Chi Minh supply routes intensified. By 1968 the AAA defenses surrounding the trails routes had become so formidable that USAF AC-47 gunships and flare-dropping aircraft had to relocate their operations. In 1969 the defenses in Laos and throughout North Vietnam increased again as AAA batteries were finally released from the defense of cities and ports in the north, where they had been kept on alert despite the cessation of *Rolling Thunder* in November 1968.

CHRONOLOGY

1952

June 12 A contract for one XA4D-1 (BuNo 137812) is issued by the US Navy, funded by cancellation of the Douglas A2D Skyshark turboprop attack aircraft.

June 21 An order for nine A4D-1s is placed with Douglas Aircraft.

November Manufacture of the ten aircraft begins.

1953

January Tooling for the A4D is completed.

1954

February The XA4D-1 is rolled out and named Skyhawk.

March Gen Vo Nguyen Giap's Viet Minh forces defeat the French at Dien Bien Phu.

June 22 Test pilot Bob Rahn makes the first XA4D-1 flight.

August 14 The first pre-production A4D-1 flies.

1955

September Initial A4D carrier qualifications completed aboard USS *Ticonderoga* (CVA-14).

October 15 A4D-1 BuNo 137820 flown by Lt Gordon Gray sets a low-level 500km closed-circuit speed record of 695.163mph.

October VA-72 becomes the first operational US Navy Skyhawk squadron.

1956

December VMA-224 becomes the first US Marine Corps Skyhawk unit.

1957

September Work on the A4D-2N begins.

1958

August 21 First flight of A4D-2N.

1959

June Development of the Ho Chi Minh trail network begins.

The second A4D-1, with the original tail-cone and externally skinned rudder, was used for "buddy" refueling trials at Edwards AFB and for service testing at the Naval Air Test Center. (US Navy)

1960

February A4D-2N enters service.

1961

July 12 First flight of the J52-powered A4D-5.

1962

September 18 US Department of Defense adopts the unified tri-service aircraft designation system, resulting in the A4D-1, A4D-2, A4D-2N, and A4D-5 becoming the A-4A, A-4B, A-4C, and A-4E, respectively.

December A-4E enters service.

The Viet Cong begin to establish AAA capability in South Vietnam using Chinese and Polish 37mm weapons.

1964

August 5 First combat use of A-4s in strikes on North Vietnam.

December The first North Vietnamese regiment is deployed to South Vietnam.

The Soviet Politburo approves military aid for North Vietnam, including SA-2s and 100mm guns, although the latter prove less effective than smaller-caliber weapons.

1965

January 7 The first North Vietnamese SAM regiment is formed.

1966

May 19 First TA-4E/F is delivered.

June 29 Air attacks on the Hanoi area begin.

August 31 First flight of the A-4F.

September Trials of the QRC-160-1 SA-2 and AAA radar jamming pod begin.

December Successful air attacks on North Vietnamese SAM and AAA positions prompt increased AAA coverage and better coordination of gun batteries.

1967

April More than 60 percent of North Vietnamese AAA batteries are tasked with the defense of Hanoi. Effective jamming of SAM radars brings a renewed emphasis on optically aimed AAA fire.

May 5 In attacks on Hanoi, jamming by US aircraft blinds the radars of 100mm and 57mm AAA guns.

May 20 A-4s attack Hanoi's electrical generating facilities with Walleye bombs, meeting fire from 18 batteries of 57mm guns and three batteries of mobile 14mm guns.

June A-4F deliveries begin.

August The use of cluster bomb units has an increasingly destructive effect on North Vietnamese AAA batteries.

October An integrated air defense plan for Hanoi is stepped up, including 14 AAA regiments with 1,000 guns and 26 missile battalions.

1968

November 2 Operation *Rolling Thunder* ends.

1969

April TA-4J deliveries begin.

1970

April 10 First flight of the A-4M.

1972

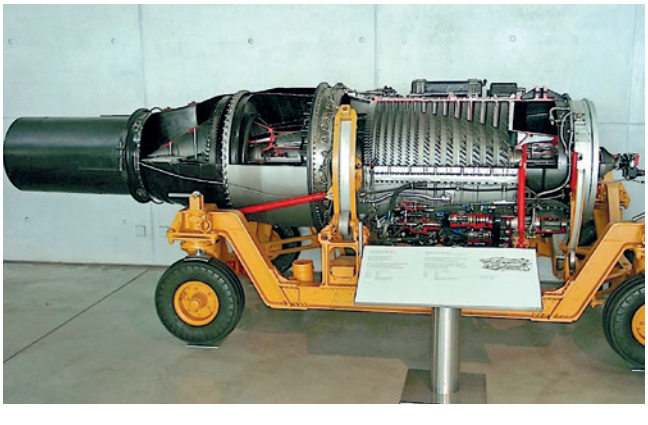
September 25 USS *Hancock* (CVA-19), with VA-55 and VA-64 embarked as part of CVW-21, completes its final online period off Vietnam during its 1972 cruise, thus ending the A-4's combat commitment to the campaign.

DESIGN AND DEVELOPMENT

A-4 SKYHAWK

Ed Heinemann's minimalist philosophy permeated every part of the A4D's design. For its avionics, he saw that many aircraft had their electronic navigation and communications components arranged randomly around the airframe, connected by lengthy cable looms. In the Skyhawk, he concentrated them all into one unit, with a single multi-pin connector. The Douglas-designed ejection seat weighed 31lbs, half as much as other widely used models. Heavy wing-folding mechanisms were avoided by making the 27.6ft wingspan fit the deck-lifts of contemporary aircraft carriers.

Ben Collins' team made the undercarriage forward-retracting, preserving the structural integrity of the wing box. The rear fuselage was extended to reduce "base drag" that occurred around the rear of a delta wing. First-hand study of aircraft carrier operations in the Korean War increased the practicality of the A4D



A Wright J65 turbojet engine, with internal features displayed. (Kogo/Wikipedia)

design for combat use. Gross weight was settled at 15,000lbs, while the empty weight was still only 8,136lbs. By February 1953 the mock-up had been constructed, modified in the light of US Navy proposals in September 1952, and approved. With more powerful engines, the later versions of the aircraft would carry up to 12,000lbs in fuel alone and operate at gross weights exceeding 27,000lbs for land operations.

Heinemann chose the Armstrong Siddeley Sapphire as the best, most powerful engine available at the time. Production versions used in variants of the Hawker Hunter, Gloster Javelin and Handley Page Victor had been the first British engines to exceed 10,000lbs thrust. However, the license-produced J65 suffered from adaptation to American production and standardization methods, reducing thrust to only 7,500lbs. To cut costs, Douglas was required to use reconditioned J65s from USAF F-84F Thunderstreaks that developed only 7,200lbs and suffered from frequent bearings failures.

Frustrated by this lowering of expectations, Heinemann approached Rolls-Royce to explore using its 10,000lb thrust Avon as a back-up option. Unfortunately, Rolls-Royce was then securing a US license-production deal with Westinghouse, preventing a straightforward purchase. When the resulting Westinghouse XJ54 engine appeared, Heinemann was disappointed once again. Funded by the US Navy but modified by Westinghouse, it produced only 6,000lbs of thrust! With the J65 as his only option, Heinemann encouraged Wright to improve the engine, and by 1959 the thrust was increased to 8,500lbs in the J65-W-16A.

After the first flight of the prototype A4D-1 BuNo 137812 on June 22, 1954, two years after the project was approved, the test program included a record flight and a "first" for an attack aircraft in the form of the 100m closed circuit speed record, flown at an altitude of just 300ft and at an average of 695.163mph by the third A4D-1. Deliveries of this model began in November 1956, followed by the A4D-2 (A-4B) from September 1957 and the radar-equipped A4D-2N (A-4C) from February 1960.

On July 12, 1961 the first A4D-5 (A-4E) was ready to fly, this variant being fitted with a new engine. Originally intended for four A4D-3 (A-4D) prototypes, the Pratt & Whitney J52 was derived from the company's widely used J57 (JT3) two-spool turbojet. Funding issues brought the cancelation of the A4D-3 with its limited all-weather, radar-based navigation and attack systems, funded in 1955 by the US Navy and later upgraded for the Grumman A-6 Intruder. The J52-PW-6 initially fitted in the A4D-5 gave roughly the same 8,500lbs thrust as late-build J65s, although its fuel consumption was appreciably lower – the A4D-5's range was increased by 27 percent.

Like the J65, the J52 was also relatively smokeless, which increased the Skyhawk's survivability and also helped to make the jet a capable MiG simulator in its later role as an adversary aircraft for training US Navy and US Marine Corps fighter crews. Ed Heinemann had hoped to use the very economical Rolls-Royce Spey engine in an improved Skyhawk, and four years after his departure from Douglas Aircraft in 1960, it was considered as a means of giving the A-4 a 4,000lb bombload boost and a tactical radius increase from 200 to 600 miles. However, British delays in sanctioning the Spey for military projects curtailed its use in the jet. A-4Es entered frontline service in January 1963 with VA-23 "Black Knights," and the similar A-4F with an avionics "hump" arrived three years later.

Two-seat Skyhawks were ordered quite late in the procurement process, despite having been included in the original Douglas development plan. Losses in the Vietnam War compelled A-4 training units to release single-seat aircraft (some of which had

OPPOSITE

A-4E BuNo 151084 of VA-94, embarked in USS *Bon Homme Richard* (CVA-31) in 1972, is depicted here configured for flak suppression. A number of E-model Skyhawks had the A-4F dorsal avionics packs, which VA-94 used to display nicknames such as *PINOCHILE* (spelled *PINOCHLE* on the left side!), which was NF 406 for VA-94's combat cruise on board CVA-31 in 1970.

A-4E SKYHAWK

40ft 1.5in.

15ft 2in.

27ft 6in.

An internal battery was omitted from the Skyhawk to save weight, so the aircraft relied on external power (left) until its engine was started. Fully armed, this A-4F from VMA-211 will shortly be hooked up to the power cart being pulled in its direction by a Marine groundcrewman at Chu Lai air base in South Vietnam. (US Marine Corps)

been designated TA-4As or TA-4Bs), hastening the release of funds for a TA-4 version of the A-4F model. The new aircraft retained its full ordnance capability but sacrificed 140 US gallons of internal fuel to fit a second cockpit.

BUILT FOR BATTLE

The A-4 was capable of withstanding considerable battle damage, although, as with many of its contemporaries in the Vietnam War, the aircraft lacked protection for its crucial electrical and control systems. Furthermore, the latter were often situated close to the aircraft's exterior surfaces. An area below and behind the pilot's seat (known to maintainers as the "hell hole") housed numerous control junctions and electrical busses, and a hit or two there could knock out the flight controls almost immediately. Cdr Harry Jenkins, CO of VA-163 embarked in USS *Oriskany* (CVA-34), was brought down in this way on November 13, 1965 near Dong Hoi when two shells from a lone 37mm gun hit his A-4E "Old Salt 340" (BuNo 151067) at very low altitude.

Conversely, the A-4's survivability would be epitomized by Lt Cdr Dennis Weichman's VA-164 jet that made it back from the first raid on Phuc Yen MiG base with 140 holes and much of its nose missing. In the first Walleye guided bomb attack on Hanoi's thermal power plant, an A-4E returned with an elevator missing and 127 holes in its starboard wing, which had also been warped by fire. Another A-4E had a hole three feet wide in one wing. There were many similar incidents throughout the conflict in Southeast Asia.

The "buddy" refueling system, introduced at the insistence of Adm Thomas H. Moorer, Commander-in-Chief of the US Pacific Fleet, added to the A-4's combat capability. Designed by Heinemann in another concentrated overnight creative session, it used an Aero-1A-type streamlined shape with a propeller-driven hydraulic pump and hose-reel system to transfer 300 gallons of fuel from the store's tank (and more from the aircraft's internal fuel tanks) to other aircraft via the US Navy probe-and-drogue refueling method. It was carried on the centerline pylon. Heinemann had worked on minimum-drag Aero-1A external stores for his F3D Skyknight fighter, and they provided the aerodynamic shape for most subsequent US external tanks and low-drag bombs. Buddy refueling by A-4s was estimated in 1966 to have saved 380 aircrew by supplying fuel-starved aircraft. It could also be used for long-distance transit flights – an example of this was when the US Marine Corps buddy-refueled Skyhawks across the Atlantic. Extended endurance caused some personal disadvantages for pilots, however, as they had to suffer long flights without a relief tube in the A-4!

NORTH VIETNAMESE AAA WEAPONS

Although MiGs and SAMs proved to be formidable threats to Naval Aviators over North Vietnam and Laos, the majority of losses were due to AAA. In fact, the latter

accounted for 52 percent of US Navy casualties and 83 percent of USAF aircraft destroyed. US Navy A-4 Skyhawk units suffered 271 losses, with 98 pilot fatalities.

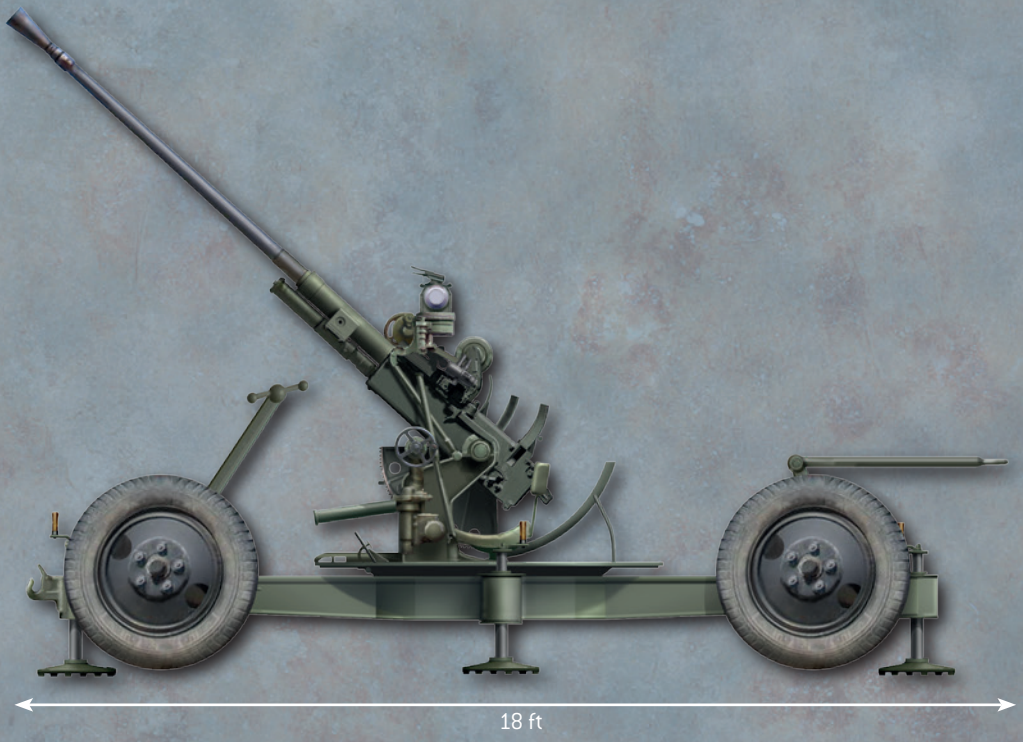
The most frequently encountered weapons were the 23mm ZU-23-2 and 37mm M1939 (61-K) cannon supplied by both the Soviet Union and China. A single hit by a 37mm round could cripple an A-4. For example, VA-163 A-4E BuNo 151083, flying from *Oriskany*, had its starboard horizontal tailplane blown off by a solitary 37mm shell as it made a low-level, high-speed egress from the target area after dropping Snakeye bombs on the Hai Duong bridge on November 17, 1965 – a raid in which four of the attacking aircraft were lost. The pilot, Lt Cdr Roy Bowling, ejected at an altitude of 150ft and did not survive.

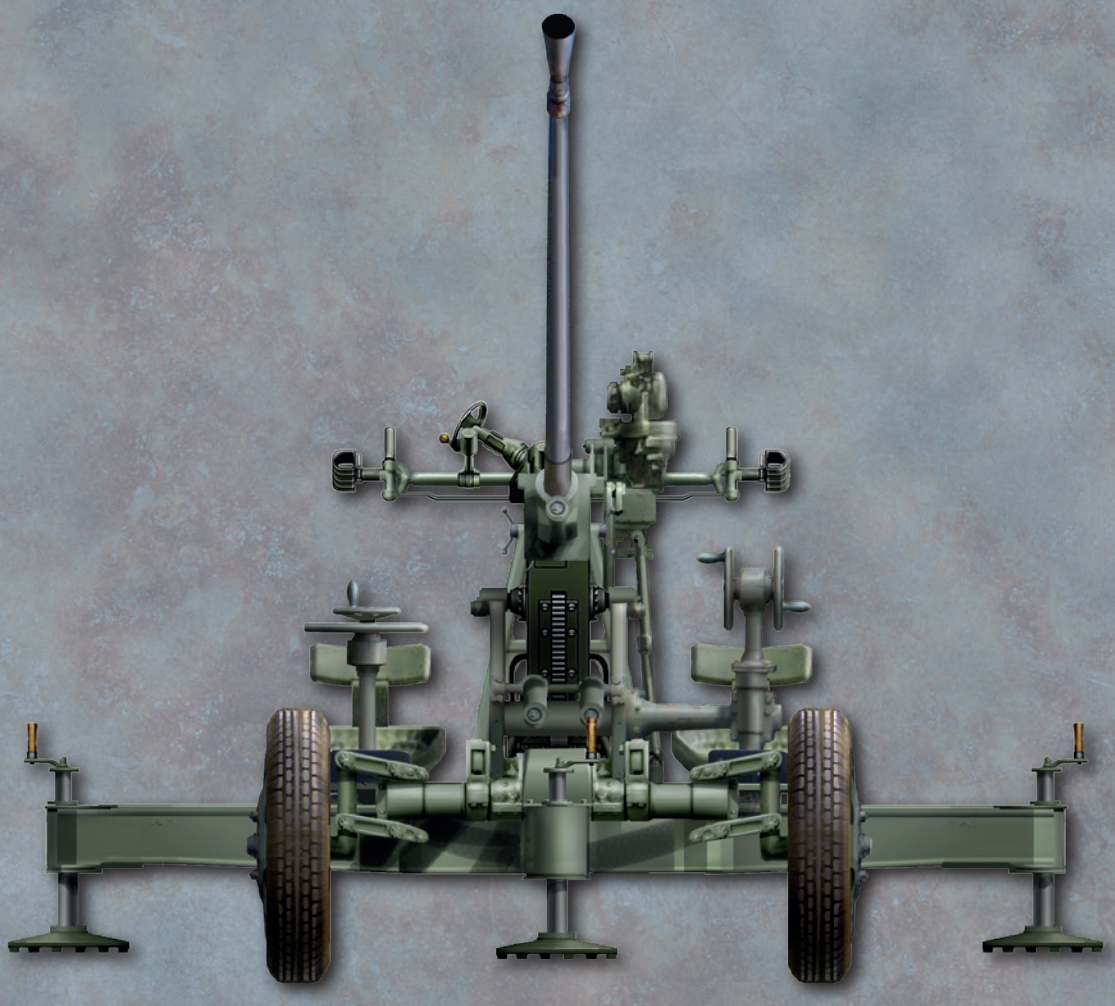
A burst nose-wheel tire seems to be the least of this flak-damaged A-4C's problems. The jet, assigned to VA-192, made two war cruises in 1964–65 embarked in USS *Bon Homme Richard* (CVA-31). (US Navy)

The standard Warsaw Pact light automatic AAA gun until the early 1960s was the AZP S-60 57mm weapon, which originated from Soviet State Factories in 1950. Supplied to at least 32 client countries, including North Vietnam, it is still in active use in Iraq, Syria and Yemen. Designed by V. G. Grabin, the S-60 was based on captured German 55mm Gerät 58 and 50mm Flak 41 guns and tested in 1946. During the 1950s it replaced the World War II-vintage M1939 (61-K) 37mm gun in Soviet service. AAA regiments were usually composed of between two and four batteries, each with six guns – a model that the North Vietnamese copied.

North Vietnam also benefited from the Soviet Union's decision in the 1960s to follow US and British policies and replace many of its AAA guns with ground-to-air missiles. Among its AAA weapons, the USSR had produced in excess of 20,000 M1939 (61-K), and more were made in Poland, China and North Korea. Many of the weapons

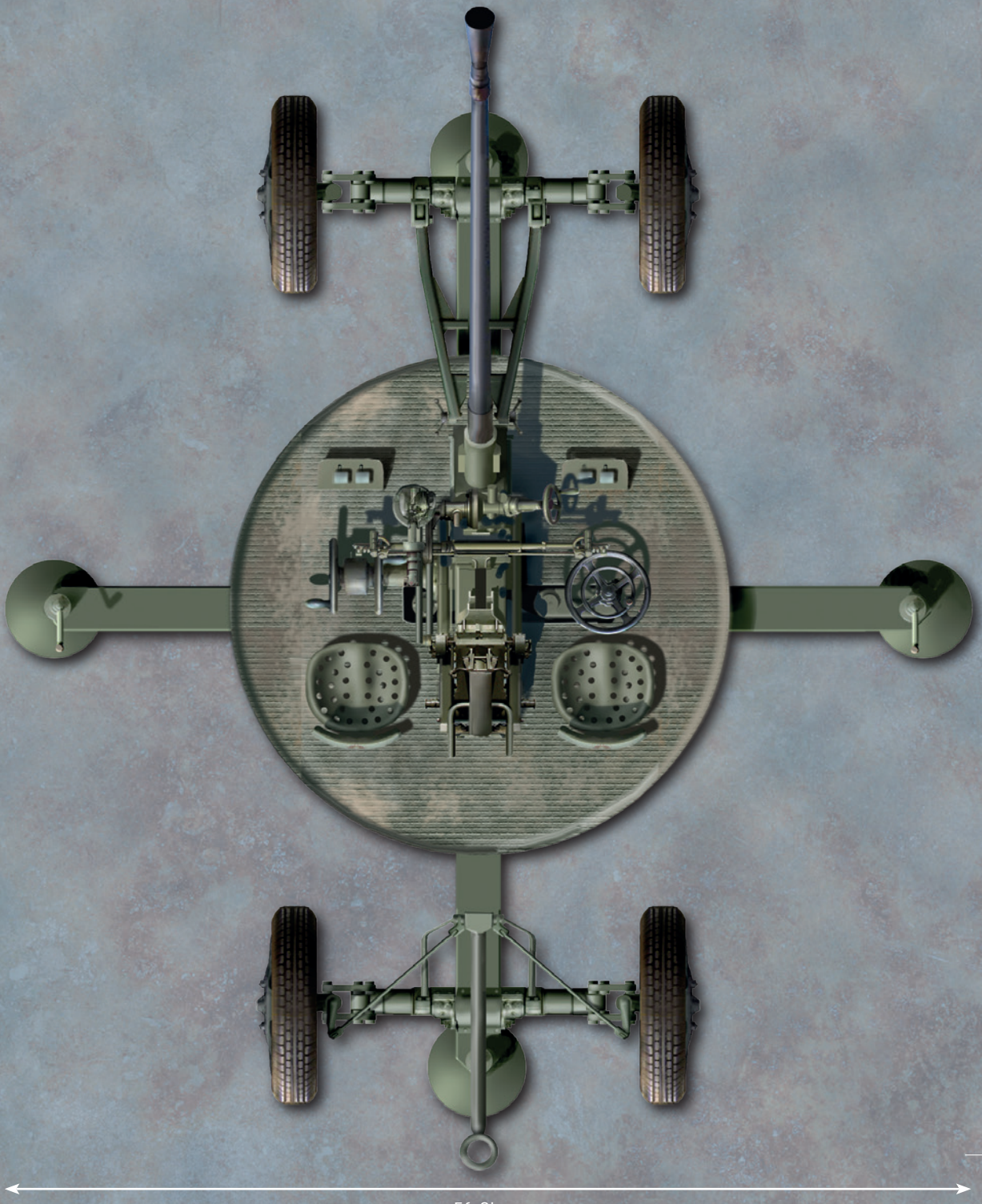
VA-83 A4D-2 BuNo 145006, embarked in USS *Forrestal* (CVA-59), buddy-refuels RF-8A Crusader BuNo 146829 from VFP-62 Det 42-60 during the carrier's Mediterranean cruise of 1960. Both of these aircraft would be lost in flying accidents in 1962. (US Navy)


18 ft


7ft

M1939 (61-K)

The Soviet M1939 (61-K) 37mm gun was the AAA weapon most frequently encountered by A-4 pilots. Developed from the Bofors 25mm Model 1933, it entered service in 1939 and 20,000 were produced, with others made in China, North Korea and Poland. The gun's barrel length was 8ft 10in., overall length was 18ft and width was 5.8ft (without the extended supporting beams).



5ft 8in.

An S-60 57mm gun with a PUAZO-6 fire director to its left. As a comparative lightweight at five tons, the S-60 was easily moved to forward bases behind a six-wheel Ural-375 or ZIL-157 truck. (Public Domain/Bukvoed)

deemed to be surplus to requirements as a result of the Warsaw Pact's wholesale switch to SAMs were eagerly snapped up by the North Vietnamese. Although the conflict in Vietnam would remind the Soviet Union of the importance of AAA in conventional air defense, many of its more modern 57mm S-60s also became available for transfer to North Vietnam, where they were very effective against aircraft flying at between 1,200 and 4,500ft.

S-60s could operate with the PUAZO-5A fire direction device, which originated as a wartime German design, the Lambda calculator or *Kommandgerät* 40. All three were replaced by the Soviet-designed RPK-1 Vaza distance-measuring instrument, part of the SON-9 system that relied on a Grom-2 radar working on a 10cm wavelength. The gun was re-designated S-68 for a twin-barrel installation mounted in the ZSU-57-2 "Sparka" Soviet self-propelled anti-aircraft gun (SPAAG). Based on the T-54 tank chassis, it had a lengthy gestation period before entering Soviet service in 1955. The SPAAG's production run lasted only until 1960 (by which time 5,300 had been built), although North Korean copies combining the Chinese Type 59 chassis (a copy of the T-54) and decommissioned ZSU-57-2 turrets sourced from the USSR were constructed between 1968 and 1977.

Although its mobility was useful in establishing unexpected "flak traps" in North Vietnam, the SPAAG's accuracy was compromised by the lack of the SON-9 and PUAZO fire direction equipment used for static S-60 batteries. At least 500 surplus SPAAGs were supplied to North Vietnam, and the North Vietnamese gave the type its combat debut in-theater during the country's Easter Offensive in 1972.

The accuracy, ammunition capacity and rate of fire of the "Sparka" were soon found to be inadequate in Soviet use, and it was replaced by the ZSU-23-4 "Shilka," a four-barrel 23mm mobile unit with RPK-2 "Gun Dish" radar guidance. It was inspired by World War II designs such as the quadruple 20mm *Flakvierling* anti-aircraft system and the similar American Maxson M45 Quadmount. Mounted on a thinly armored, tracked vehicle chassis derived from the PT-76 light tank, the four 23mm 2A7 guns could together deliver up to 4,000 rounds per minute. "Shilka" would accompany armored convoys and quickly direct its high rate-of-fire at low-flying aircraft, with deadly effect. In Vietnam up to 100 appeared in 1973, although other versions of the 23mm gun had been the mainstay of North Vietnam's AAA forces from 1965 onwards when supplies of the twin-barrel ZSU-23-2 began to arrive from the USSR. This weapon had been in Soviet service since 1960 as a towed unit, or mounted on armored personnel carriers or trucks.

Of the 140,000 produced and used by at least 20 countries, many ended up in North Vietnam. The ZSU-23-2's simplicity enabled it to be activated within a few

minutes and aimed optically through a ZAP-23 sight by a two-man crew. Comparatively light, at 2,094lbs it could be towed through rough terrain and operated by militia crews. It remains in service in many countries, and has appeared in action during the civil war in Syria.

The ubiquitous M1939 (61-K) had a long history dating back to 1938 when Mikhail Loginov at the Sverdlovsk Artillery Factory No. 8 developed a 37mm version of a gun based on the Swedish Bofors 25mm weapon, bought by the Soviet Navy in 1935. It became the country's first mass-produced anti-aircraft gun, and more than 20,000 were manufactured by 1945, with many others made in China, Poland and North Korea. Firing at 160 rounds per minute, it was responsible for shooting down hundreds of US aircraft.

North Vietnam's heavier AAA weapons originated in the 1940s. Production of the M1939 (52-K) 85mm gun was completed by 1945. Designed by a team led by M. N. Loginov and G. D. Dorokhin, it was widely used against Luftwaffe bombers or as an anti-tank weapon, as its armor-piercing AP-T rounds could penetrate 185mm steel plate. Supplied to most Soviet bloc countries, it saw widespread use in North Vietnam, where pilots at medium and high altitudes became used to seeing its black shell bursts. In the Soviet Union the 52-K was replaced by the 100mm KS-19 (used in the Korean War) from 1949, and it was paralleled by the 130mm KS-30 as a high-altitude gun. 52-Ks were phased out of Soviet use in favor of SAMs.

By 1968 the North Vietnamese also had many thousands of lighter AAA and infantry weapons, of which the Chinese Type 67 7.62mm machine gun, introduced in 1967, was among the more modern and the 7.62mm SG-43 Goryunov was a World War II Soviet stalwart. Even older, but used throughout the war, was the heavier DShK 1938 12.7mm weapon designed by Vasily Degtyaryov and Georgi Shpagin as a version of the 1930 DK machine gun – roughly equivalent to the US Browning M2 0.50-cal machine gun. Mounted on tripods, tanks or trolleys, the DShK was issued to militia groups as a simple, reliable and potentially deadly weapon against aircraft flying below 5,000ft. Pilots became used to seeing the tracers from these guns, rising in poor light "like a stream from a garden hose."

In addition, troops had access to captured US 0.50-cal machine guns, ex-French booty and a wide range of older infantry rifles and small arms, all of which could be lethal when used for massed barrage fire. However, in the competition between China and the Soviet Union to supply North Vietnam with the most effective anti-aircraft weapons (thereby securing dominance in the world communist movement), the USSR had the most impressive offerings in the form of its SA-2 SAMs and their associated radar technology.

The M1939 (52-K) 85mm gun was extensively used in the defense of Hanoi. Indeed, it is estimated that almost 60 percent of North Vietnam's 52-K and KS-19 100mm batteries were positioned around the city. (Public Domain)

TECHNICAL SPECIFICATIONS

A-4 SKYHAWK

In an A-4's small but functional cockpit, the pilot had the throttle, flap lever and a manual trim control for the horizontal stabilizer on his left side panel. There was a main electrical trim switch on the front of the control column grip and a rudder trim knob on the left side panel. Main instruments on the front panel showed performance figures, engine and fuel details, very often combined into one multi-function dial to save space. The weapons panel, which worked in conjunction with the complex AJB-3 (nicknamed "abbajabba" by Naval Aviators) weapons delivery computer was on the lower central panel, with a switch to adjust the seat.

Most of the wing was a 568 US gallons fuel tank, with another 1,600lbs in a tank behind the cockpit. The wing had a higher load factor than the US Navy required, allowing for future weight increases. Its leading edge housed the three-light array to give the carrier landing signals officer information on the aircraft's speed and attitude on approach to the deck. An orange light showed the aircraft was "on speed," a red light indicated inadequate speed and green meant "too fast." Above the instrument panel was an indexer that repeated the pattern of these lights so that the pilot could judge his approach speed. The indexer was in his line of vision on approach, together with the other key instruments he would need to monitor to ensure a successful deck landing.

VA-155's CAG A-4E BuNo 149991 rolls over arresting wires on board USS *Coral Sea* (CVA-43) towards the catapult carrying Mk 82 bombs fitted with fuse extenders. Lt Cdr Wendell Rivers, on his 96th combat mission, was hit by AAA in this aircraft during a 45-degree dive on the power station at Vinh on September 10, 1965. He turned his blazing aircraft seawards but the controls burned through, forcing him to eject into captivity. Rivers had participated in the *Flaming Dart* attacks in March 1965. (US Navy)

The undercarriage retracted forwards, with the main struts rotating for the wheels to lie flat in their wells. All three struts were long enough to accommodate a 30in. diameter Mk 7 bomb beneath the aircraft, but their length, location and absence of nose-gear steering could make the Skyhawk susceptible to tipping over on the flightdeck. The undercarriage was longer than Heinemann intended because the US Navy insisted on avoiding tail-scraping landings – common among swept-wing jet types. The nose-wheel strut was compressed on retraction to fit into its well. On a catapult launch it also compressed at full power. Nose-wheel steering was unavailable before the A-4F, so differential braking was the only way of steering earlier variants. There was no back-up braking system. If the brakes failed, or one or more of the landing gear members would not lower or lock, the pilot was advised to retract the other wheels and belly-land on the empty 300-gallon drop tanks.

The flying controls were relatively simple. Leading edge wing slats were operated by airflow and gravity, extending at low speeds to improve handling. On a catapult launch or high-G maneuver, they would slam shut and also provide a quick visual guide to lower air speeds if a pilot had cockpit instrument failure. A-4s of the US Navy's *Blue Angels* flight demonstration squadron had their slats wired shut in case of an asymmetric extension in a high-G situation, which could invert the aircraft. Both the wings and slats had vortex generators above them to prevent wing drop at high speed and guide air smoothly across the ailerons, avoiding buffeting.

Powerful ailerons, combined with the aircraft's short wingspan, could induce a roll rate of 723 degrees per minute when fully deflected – well beyond most pilots' comfort level. Such a drastic roll rate could also induce violent centrifugal outward movement of fuel in the internal wing tanks, distorting some inner bulkheads. Simple split flaps could be set to a mid-position or fully down. Speed brakes opened from both sides of the rear fuselage.

The relatively small rudder, built to an unusual weight-saving configuration with external ribs and a central, single skin, was used mainly at low speeds or on the runway. Its structure originated in XA4D-1 tests in which severe buzzing around the original externally skinned rudder caused some of the skin to peel off. Heinemann quickly devised the single-skin rudder based on a "fix" for the rudder of the North American F-100 Super Sabre.

A VMA-225 A-4C is "hot refuelled" through the aerial refueling probe – an unusual but expedient method – at Chu Lai. (US Marine Corps)

Lt F. C. Spellman of VA-22, embarked in USS *Midway* (CVA-41), launches 2.75in. Mighty Mouse folding fin rockets from an LAU-3 pod attached to the underside of the starboard wing of his A-4C (BuNo 147759) during a training mission off South Vietnam in 1965. Ironically, this aircraft was brought down off the coast near Van Ly on July 14, 1967 by a burning rocket pod that had been hit by AAA. The jet was assigned to VA-76 by then, and its pilot, Lt J. N. Donis, ejected and was rescued. Three Skyhawks were lost on this date. (US Navy)

A tailhook beneath the rear fuselage had an adjacent pressure gauge that had to be checked on the pre-flight "walk around." The hook's mounting incorporated a catapult tension bar holder that was used to hold the aircraft fast against the full thrust of its engine until the catapult shot propelled it forwards.

The Skyhawk's J65 engine, also used in the Grumman F11F Tiger supersonic fighter, had a "total loss" oil system that used and exhausted the engine oil through ports on either side of the fuselage at the rate of two pints per hour. The distinctive oil smears visible at the end of each flight distinguished early Skyhawks from the later J52-powered variants. The J52-P-6A, which developed 880lbs more thrust than the J65, was also noticeably quieter and smoother-running, as well as being 770lbs lighter. Center of gravity considerations required the engine to be mounted quite far forward in the fuselage, with a very long exhaust pipe. Early tests at Edwards AFB, California, showed that the airflow over the rear fuselage was breaking away too early, causing buffeting around that area of the fuselage and limiting speed to Mach 0.7. A "sugar cone" fairing above the jet pipe exit was quickly devised at Edwards AFB, and it was retained for production aircraft, curing the problem by decreasing the taper of the rear fuselage.

The main fuel tank and refueling boom were pressurized by an air-driven pump. Although it was a relatively simple addition, the boom had teething troubles around 1963. Its nozzle occasionally stayed open when the aircraft separated from its tanker. Pressurized fuel could then stream back out of the nozzle. It would be ingested into the air intake and cause an explosion that made the engine surge and flame out. One of *Oriskany*'s A-4Fs (BuNo 154184) was lost in this way during a July 29, 1969 combat mission when fuel spray started a fire in the engine bay, forcing the pilot to eject. For a rapid turnaround to return the aircraft to action, the probe could be used to "hot refuel" it on the ground, rather than relying on the less accessible single refueling point under the fuselage.

ARMAMENT

A-4s carried a wide range of bombs, from Korean War-surplus 131lb M30A1s and M88 fragmentation bombs through to the Mk series of low-drag general-purpose bombs – the 250lb Mk 81 and 500lb Mk 82 through to the 2,000lb Mk 84. USAF 750lb M117 demolition bombs were also used. Skyhawks were cleared for 500lb Mk 77 or 1,000lb Mk 79 fire-bombs, although several major fires aboard aircraft carriers restricted the permitted types of ordnance.

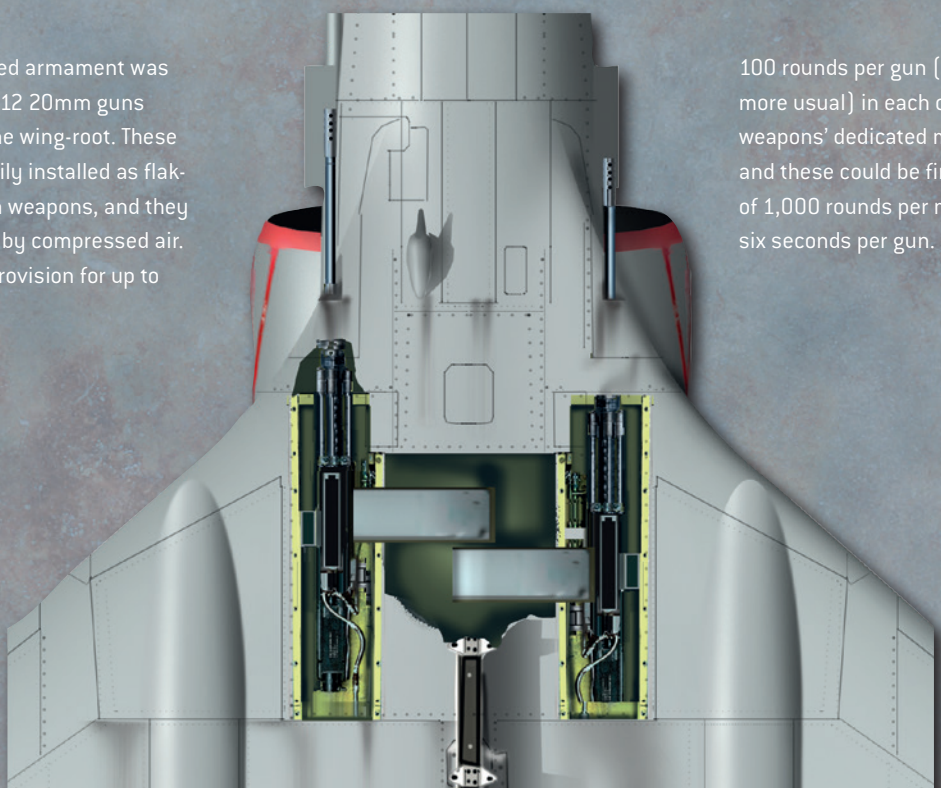
The most common load for any A-4 was six Mk 82s. Often, these were Mk 82 SE Snakeye 1s with Mk 14 fin assemblies for retarded high-drag delivery. Lt Col Bill Egen recalled that, for the US Marine Corps, "We carried Mk 81 and Mk 82 'Snakes' routinely and dropped them in the high-drag mode at 500ft AGL [above ground level] and in the slick mode [un-retarded] for a high-dive attack. We were in the 3,000ft range above the target as routine for normal un-retarded delivery 'down south', but when over North Vietnam we briefed for 4,500ft minimum altitude." Capt John Kuchinski rated the Snakeye as, "very accurate with low-altitude release at 150-200ft, but it had to be retarded."

The A-4's fixed armament was two Colt Mk 12 20mm guns located in the wing-root. In combat situations their location sometimes caused gas and debris ingestion into the air intakes. Douglas duly fitted protective "shelves" to A-4E/Fs above the gun muzzles to eradicate this problem. A-4Es quite often flew without guns installed, and TA-4s usually had only one.

Not only did the 20mm weapons tend to jam under g-forces exceeding 1g, they also flexed slightly when firing, reducing accuracy. Removing the 101lb weapon was a two-man task requiring one large panel, the magazine and some connectors to be detached. When the aircraft were fitted with electronic countermeasures (ECM) equipment in Project *Shoehorn* one gun was removed and ammunition for the other was reduced to 40 rounds. This had to be loaded from a fuselage hatch used to access the AJB-3A low-altitude bombing system (LABS) gear, rather than via the "hell hole" under the forward fuselage. Pilots regretted the loss of strafing capability but appreciated, in Vice Admiral

A-4 SKYHAWK CANNON

The A-4's fixed armament was two Colt Mk 12 20mm guns located in the wing-root. These were primarily installed as flak-suppression weapons, and they were driven by compressed air. There was provision for up to



100 rounds per gun (90 was more usual) in each of the weapons' dedicated magazines, and these could be fired at a rate of 1,000 rounds per minute, or six seconds per gun.

A-4F BuNo 155057 of VA-155 weighed down with a load of 12 Mk 82s, two AGM-12B Bullpups on the outer pylons and an AGM-62 Walleye on the centerline. VA-155 transitioned to A-4Fs at NAS Lemoore in the summer of 1968 after an action-packed A-4E combat cruise aboard *Coral Sea*, during which the squadron delivered more than six million pounds of ordnance. (US Navy)

Bob Dunn's words, "a modicum of electronic warning and anti-AAA and anti-SAM capability" instead.

Hughes Mk 4 Hipeg gun pods were an option from 1965 for extra strafing firepower. Each pod contained a Mk 11 twin-barrel, air-cooled revolver gun and 750 20mm rounds. Three could be carried with a total load of 2,250 rounds and an impressive combined rate of fire of 12,600 rounds per minute, with cooling-off pauses every few seconds. The recoil from two pods fired simultaneously knocked up to 100 knots off a diving Skyhawk's speed. Used by US Marine Corps units in South Vietnam, the pod proved to be somewhat unreliable. For use from carriers, the pod could take only a half-load of ammunition. Otherwise, if it jammed after only a few rounds, it would make the A-4 too heavy for a carrier landing.

LAU-3 pods with 19 2.75in. Mighty Mouse folding fin rockets were widely used. When all projectiles were fired simultaneously they could collide or disintegrate in flight, damaging the launch aircraft. A VA-212 A-4E (BuNo 151179) ingested rocket debris on a May 1, 1966 convoy attack near Vinh, causing an engine fire and obliging Lt R. H. Mansfield to eject. A VA-55 A-4E (BuNo 151034) was lost in a similar fashion the following day, and two were destroyed in August, with ingested rocket debris as the most likely cause. In the case of Lt Cdr Richard Stratton's VA-192 loss on January 5, 1967, rocket debris ingestion was so severe that the entire engine exploded, blowing the tail section off his A-4E (BuNo 151136) as he attempted to turn away towards the sea and safety. Stratton became a PoW, suffering dreadful torture in a Hanoi jail. Similar accidents continued into 1968, Lt E. J. Killian of VA-212 having to eject from his A-4F (BuNo 154174) on May 30 when it ingested rocket debris from an LAU-60 pod during an attack on an oil storage site northwest of Vinh.

The 5in. Hunter-Douglas Zuni rocket, in a four-shot LAU-10/A launcher, was a more powerful and accurate alternative to an LAU-3. As a 107lb scaled-up version of the 2.75in. rocket, it could be fitted with six different types of high-explosive, incendiary or armor-piercing warheads. With a Mk 191 fused warhead, it could penetrate three feet of reinforced concrete or two inches of armor, making it a lethal weapon against anti-aircraft installations. Flak suppression A-4Es embarked in USS *Kitty Hawk* (CVA-63) in 1967 often carried four Zuni pods, and for one-pass attacks they could all be fired together. A Zuni rocket had a five-mile range at 1,600mph. However, if the pilot wanted to improve his accuracy the weapon had to be launched at a closer range to the target. Furthermore, it would only guide precisely if all four of its tail fins opened properly.

Famously, one of three Zunis fired by former F-8 Crusader pilot Lt Cdr Theodore Swartz of VA-76 from his A-4C (BuNo 148609) while on a flak suppression mission over Kep airfield achieved the Skyhawk's solitary MiG kill over Vietnam on May 1,

1967. Swartz then went after a second MiG-17, only for his single gun to suffer from persistent jamming. The MiG-17 that he did destroy, however, avenged the only loss of an A-4 to a MiG-17 six days earlier. Squadronmate Lt Charles Stackhouse was in pursuit of a MiG-17 that was chasing his wingman when he was in turn shot down in A-4C BuNo 147799.

Lt Col Bill Egen rated Zuni highly for the US Marine Corps' close air support (CAS) missions, relieving troops in close contact with the enemy. "Zuni was favorite. We called it soft ordnance. Mk 81 Snakeyes, napalm and Zuni were used for close-in deliveries. Many times the sight of the flames broke off the enemy contact, and with Zuni and guns you could get in relatively close to the good guys." A series of fires on Task Force (TF) 77 carriers associated with Zunis meant that some vessels, including *Hancock*, would not take them aboard for the later stages of the war.

The lightweight Douglas RAPEC rocket ejection seat. Although its appearance changed little in three major development stages from the original A4D-1's NAMC Type II to the ESCAPAC 1C-3 model for the A-4F, the later models crucially offered zero-zero performance. (US Navy)

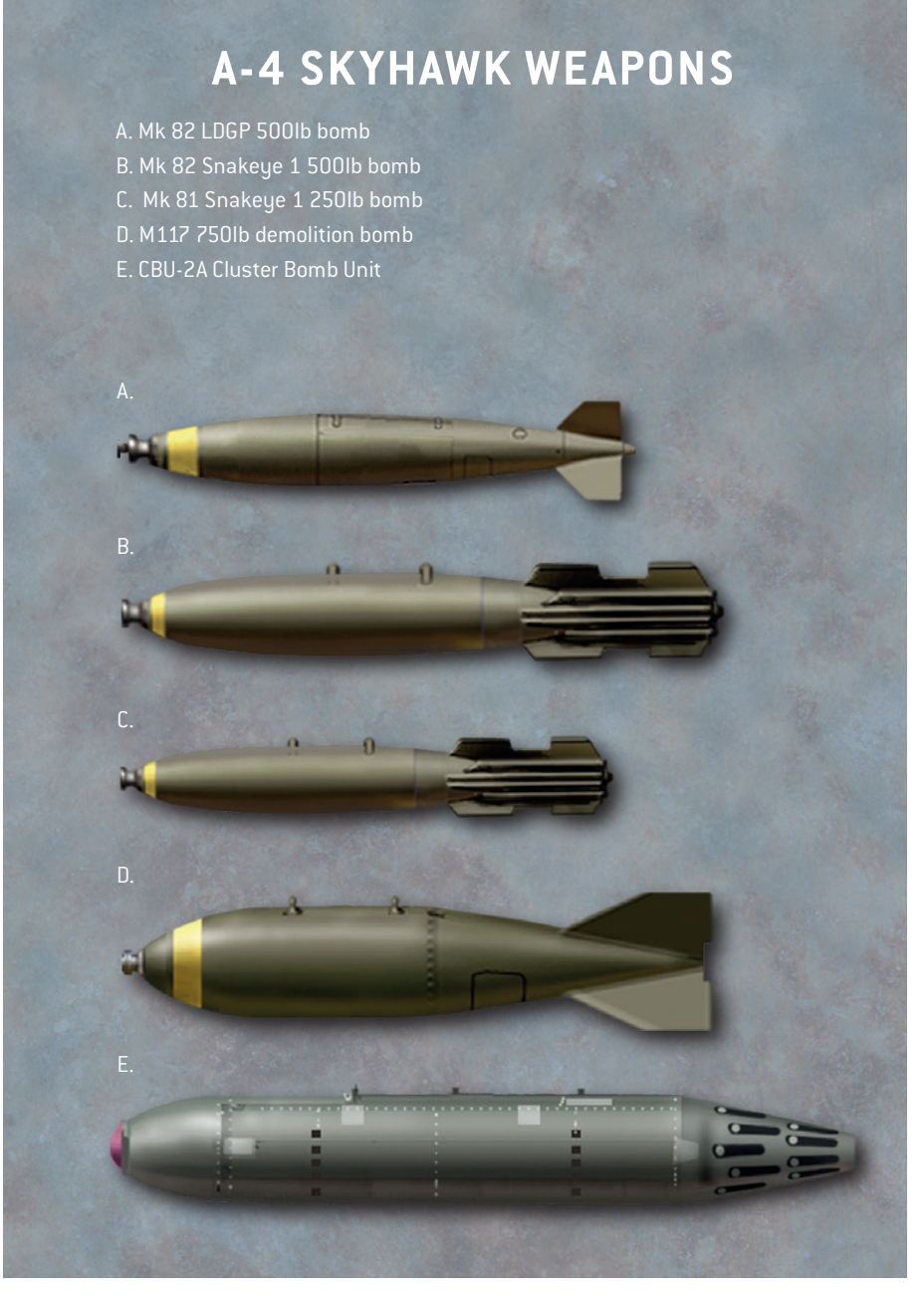
The Martin AGM-12 Bullpup was a stand-off weapon, launched from beyond the range of AAA. The AGM-12B "Little Bullpup" had a 250lb warhead, while the improved AGM-12C "Big Bullpup" delivered a 970lb warhead. Powered by a Thiokol LR58 liquid-fuel rocket engine, a 571lb AGM-12B flew for up to seven miles, while the more powerful LR62 rocket in the AGM-12C drove that 1,785lb weapon for ten miles at Mach 1.75.

In frontline service, Bullpup operations posed problems. Ironically, although the weapon had been procured because of its "stand-off" capability, in reality a pilot employing a Bullpup was *more* vulnerable to AAA. According to Capt John Kuchinski, who flew A-4s with VA-94:

> Bullpup was an early precision weapon that didn't work that well. I only used the "Little Bullpup", and it was always at a specific target like a bridge. You would roll in at about 20,000ft and line up the target in your gunsight, pull the power back to idle and drop the weapon. A flare would ignite on the back end of the Bullpup and you would guide it into your target with a little joystick in the cockpit. Many times the Bullpup would not guide properly and go uncontrollable. It was an uncomfortable feeling to be so slow on the dive if they were shooting at you because you had to keep working the joystick and maneuvering the Bullpup onto the target until impact. They were not used for very long because a better weapon, Walleye, came along shortly thereafter. It was both very effective and reliable.

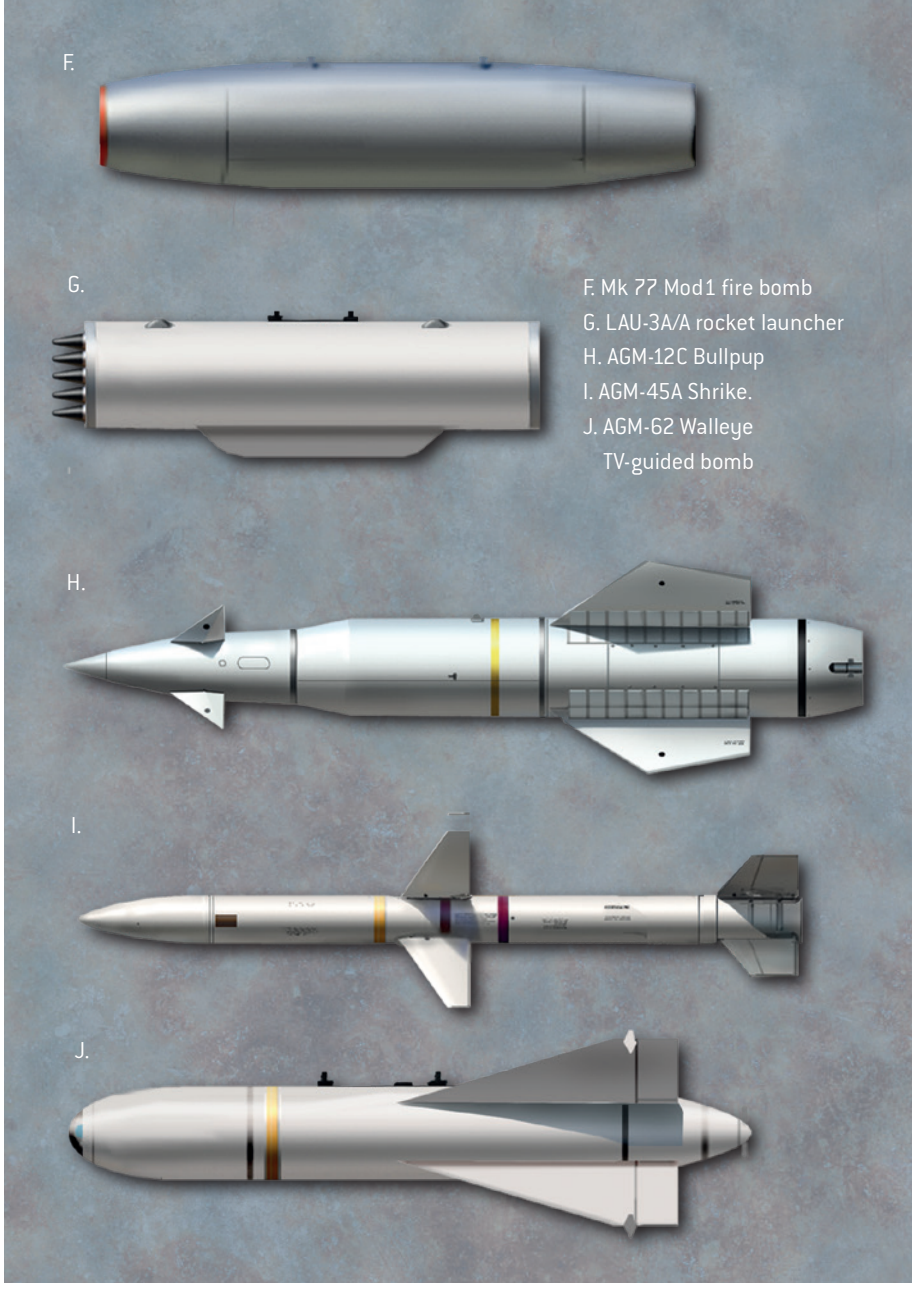
Vice Admiral Dunn had a similar experience with the "Big Bullpup":

> One had it set up in a shallow dive, pointing in the general direction of the target, with something less than full throttle. Once the target was in sight on a small scope, low and center on the instrument panel, the pilot steered the weapon by means of a tiny joystick on the right console while also attempting to keep the aircraft going straight. Imagine doing all these things simultaneously, and then realizing that the target – unlike the ranges at home – was shooting back.



On April 21 1968, Lt(jg) Jules Harper of VA-112 fired an AGM-12C at a heavy machine gun position that was defending a convoy which was under attack by the squadron. It exploded 50ft above the site, destroying it.

The Martin Marietta AGM-62 Walleye bomb was an unpowered "fire and forget" precision-guided glide-bomb. Carried on the centerline pylon of an A-4, the weapon was guided through a TV camera in its nose and a "Sony Scope" TV monitor in the cockpit. Test-dropped from an A-4B in 1963, the Walleye entered service in 1966 as the Guided Weapon Mk 1 Mod 0. VA-212 embarked in USS *Bon Homme Richard* (CVA-31) gave it a combat introduction in March of that year, launching a Walleye through the window of a large barracks at Sam Son. AGM-62s were used successfully by A-4 pilots in 1967 against the Hanoi thermal power plant and the control tower and air defense HQ at Phuc Yen air base. All five missiles launched at the plant scored



direct hits. The Walleye's 1,100lb warhead would not destroy massive structures like the Thanh Hoa Bridge despite direct hits, so a Mk 3 version was developed (and used during Operation *Linebacker II*) with a 1,900lb warhead and extended wings.

The AGM-45 Shrike was initially designed to target early-warning radar antennas. The missile had a small 149lb warhead that made it light enough at 390lbs for the A-4 to carry two (or, occasionally, four) such weapons on its outboard pylons, but not powerful enough to guarantee a knockout blow to a "Fan Song" or "Fire Can" radar van. The AGM-45 made its combat debut in 1965 with VA-23's A-4Es, and the missile was then adopted by the USAF for its *Wild Weasel* defense suppression aircraft.

On early "seek and destroy" missions against SA-2 sites, Skyhawk pilots could use the Melpar AN/APR-23 "Redhead" radar threat receiver to locate a "Fire Can" or "Fan Song" and display its range from the aircraft with a strobe on a small cockpit

screen. This provided about half the missile firing detections in 1967–68, the rest being made visually. The ATI AN/APR-25 radar homing and warning system became available in 1965 for that purpose, displaying a red light on the instrument glare shield and an aural warning for the pilot when hostile radar activity was detected. US Navy A-4s received AN/APR-26 launch warning receivers from mid-1965, the latter registering the power-boost from a "Fan Song" unit just before it launched an SA-2.

When launched, a Shrike was "lofted" into a climb of around 15 degrees three to five miles from a suspected target. This method of firing allowed the missile to arc over at 20,000ft and home onto a radar emitter within an area about a mile wide and four miles long. Alternatively, it could be fired directly at an identified emitter in a 45-degree dive at closer range. Although *Iron Hand* (anti-SAM) A-4Es could carry as many as four Shrikes, they often carried only two such weapons, with a Mk 82 bomb on each outboard pylon, or two Bullpups instead of the inboard Shrikes.

The Mk 20 Rockeye cluster bomb unit (CBU), developed by the US Naval Weapons Center as an anti-tank munition, became "the weapon of choice for our squadron [VA-55] for the 1972 bombing in North Vietnam" according to Capt Denny Sapp "primarily because of the area of coverage of the cluster bombs and their penetration of SAMs or AAA guns. A typical load-out for *Iron Hand* missions included at least two Shrikes, plus either Mk 82 bombs or Mk 20 Rockeye. If we had a target in the Hanoi area the load-out was four Shrikes and no other weapons. We wanted a clean aircraft for speed and maneuverability." Whether or not a Shrike was released at the site, "we would follow up by hitting it with Rockeye visually and could get a hard kill, not only destroying the radar van but also the launchers. If there were any SAMs on launchers or stored in the vicinity, the Rockeye would detonate them in huge secondary explosions. It could be pretty spectacular."

Surrounding AAA sites could also be hit by the CBU fused to airburst at 200ft for wide coverage, although several were needed, as each airburst made a ring of exploding bomblets with a "hole" in the center. A single Mk 20 Mod 0 CBU contained 247 Mk 118 bomblets, each with a 1.1lb warhead fragmenting into hardened steel fragments traveling at 4,000ft per second. Rockeye could be dropped from 100ft in a pitch-up maneuver. Capt Sapp recalled that the flak suppression load-out for a 1972 bridge attack near Thanh Hoa was six Mk 20s, with Walleyes on some aircraft. "Rocks," unlike Shrikes, could not be taken back to the ship in case of mishaps during an arrested landing, so they would be used up on targets of opportunity after the strike aircraft had egressed.

The A-4 could also be loaded with several types of shallow-water mines for dropping in harbors and rivers. These included the DST-26 Destructor, a 500lb Mk 82 bomb fitted with a magnetic sensor and a tail fuse. Other versions were used over land according to Capt John Kuchinski. "We dropped DSTs on certain choke-points in North Vietnam to discourage repairs of roads and bridges at night. They would bury themselves in the ground and only explode later if vehicles or people got close enough to set them off. We delivered DSTs with a standard 45-degree dive, with release at about 5,500ft so that we would be out of the dive above 3,000ft."

A-4 VARIANTS USED IN VIETNAM

A-4B

First flown on March 26, 1956, the A4D-2 (542 built) was given single-point pressure refueling to speed the turnaround time, provision for an in-flight refueling probe and more robust rear fuselage construction, together with the single-skin "tadpole" rudder and powered elevators. It could carry 5,500lbs of fuel tanks or weapons, the latter including a 3,500lb nuclear store on the centerline pylon. This required stronger landing gear. US Navy squadron VSF-3 provided Sidewinder-armed A-4B detachments to defend anti-submarine carriers, with the entire squadron being assembled to make a conventional attack deployment on board USS *Intrepid* (CVS-11) in 1967 as part of CVW-10. The air wing lost no fewer than 11 A-4s (two of them from VSF-3) to AAA and SAMs during 103 days on the line.

A-4C

Initially designated the A4D-2N, this major production version (638 built) retained the B-model's J65-W-16A or J65-W-20A engine, at 7,700lbs or 8,400lbs thrust, respectively, and added an improved autopilot, terrain-clearance radar and AJB-3 LABS. Vice Admiral Dunn recalled that "the AJB-3 was a lot better attitude indicator than the older, apt-to-tumble attitude gyro in the A-4B." TPQ-10 blind bombing equipment, an angle-of-attack indicator system and other improvements increased the A-4C's overall weight to 9,559lbs. Its limited all-weather avionics and heavy ordnance load made it a far more versatile attacker. The Escapac 1A-1 zero-zero seat was retrofitted, and there was provision for jet-assisted takeoff rockets in this and subsequent models. The A4D-2N first flew on August 21, 1958 and made its operational debut, in February 1960, with VMA-225. The jet equipped 23 US Navy and nine US Marine Corps squadrons. For its first war cruise in 1965–66, USS *Enterprise* (CVAN-65) included four A-4C squadrons within its air wing, CVW-9. No fewer than 12 Skyhawks were lost during the deployment.

A-4E

Ordered in July 1959 as the A4D-5 (499 built), this model was the first of a new generation of J52-P-6A-powered Skyhawks that boasted two additional underwing pylons, allowing a total ordnance load of 9,155lbs – roughly the same as its empty weight. Some aircraft ("Super Echoes") had the A-4F's J52-P-8A engine, giving 9,300lbs of thrust rather than 8,500lbs

Access for the AN/APG-53A radar in the Skyhawk was via an upward-hinged door, as seen here on A-4E BuNo 151406 of VMA-311 at Chu Lai on November 29, 1967. Access doors were built into the raised section, one on the left side and two on the right. The light-colored housing for the radar's transmitter and receiver group is visible. Armed with Mk 82 Snakeye bombs, this aircraft served with VMA-311 from 1967 through to 1974. (US Marine Corps)

of the J52-P-6. The A-4E's new maximum gross weight of 24,500lbs required local strengthening of the airframe around the catapult hooks and alterations to the center fuselage profile. The enlarged, re-profiled air intakes had short ramps to handle boundary-layer air. A-4Es had a radar altimeter embedded below the left wingtip and introduced windscreen wipers. The jet's longer nose (extended by 14in.) housed an AN/ASN-19A navigation computer and (later) an ALQ-100 ECM receiver, with antennas on the rear fuselage. The A-4E's navigation/attack equipment was upgraded with TACAN, the AJB-3A LABS, Doppler navigation, a radio altimeter and Mk 9 toss-bombing computer.

A-4F

Vietnam losses were the main impetus behind ordering the A-4F (146 built), which was essentially an A-4E with some upgrades, including the more powerful J52-P-8A or 11,200lbs thrust J52-P-408, fitted to 100 F-models. This slightly longer engine required an increased air intake area. Other innovations were the Escapac 1C-3 zero-zero ejection seat, nose-wheel steering and a dorsal "hump" (retro-fitted to some A-4Es) containing the Sanders AN/ALQ-51/100 deception repeater ECM, Itek AN/APR-25 radar homing and warning system (later replaced by a Bendix AN/APS-107) and Magnavox AN/APR-27 SAM launch warning system that had previously occupied the space for one of the wing-mounted guns in the A-4C. An AN/APR-23 also indicated the direction of the radar threat. A Tracor AN/ALE-29A chaff and flare dispenser was installed to defeat enemy radars.

Spoilers were added to the upper wing surface, and the forward end of the refueling probe was "bent" outwards from the fuselage to avoid interference with the target identification and acquisition system (TIAS) that replaced the radar in the nose. TIAS gave the pilot more exact warnings of the location of "Fan Song" and "Fire Can" radars than a Shrike's passive antenna could offer. Used in connection with the Shrike Improved Display System, it showed the A-4F pilot the locations of all the radar emitters and their electronic characteristics so that he could choose the most urgent threat as a Shrike target. Capt Denny Sapp recalled that his squadron (VA-55) had six TIAS-equipped A-4Fs in 1972 and six pilots who were specially trained for *Iron Hand*. In the TIAS A-4F, "the nose radar was replaced by a Shrike seeker head that coupled to a radar screen in the

This TIAS-equipped A-4F of VA-212 on board USS *Hancock* (CVA-19) is fitted with a buddy refueling store. It is highly likely that the aircraft is BuNo 155021, which became the last Skyhawk lost in combat by the US Navy on September 6, 1972 when it was hit in the tail by 23mm AAA during an armed reconnaissance mission south of Thanh Hoa. Lt W. F. Pear managed to fly the burning jet out over the sea before ejecting, and he was quickly rescued by a US Navy helicopter. (US Navy)

cockpit. As long as the enemy radar stayed online we could bore-sight the radar van by looking at our cockpit radar screen, then transition to the gunsight to get a pretty good indication of the area on the ground where the emitting van was located."

The A-4F first flew on August 31, 1966, and initial deliveries went to VA-23 and VA-192 for their 1967–68 cruise with CVW-14 embarked in USS *Ticonderoga* (CVA-14).

TA-4F

Originally designated TA-4E, the TA-4F (241 built) was an A-4F-based two-seat trainer with dual controls, an enlarged canopy and a 28in. fuselage extension that reduced fuselage fuel capacity by 140 gallons. It first flew on June 30, 1965. Many were later converted to TA-4Js. A small number of TA-4Fs were used in-theater by the US Marine Corps for continuation training and liaison flights from 1967, and in the Tactical Air Coordination (Airborne) and visual reconnaissance roles with Headquarters and Maintenance Squadron (H&MS) 11, 12 and 13 from April 1968 as replacements for venerable TF-9Js. Employed as FastFAC platforms, the TA-4Fs saw considerable combat all over South Vietnam and neighboring Laos from the units' bases at Da Nang, Chu Lai and Bien Hoa. At least five examples were shot down.

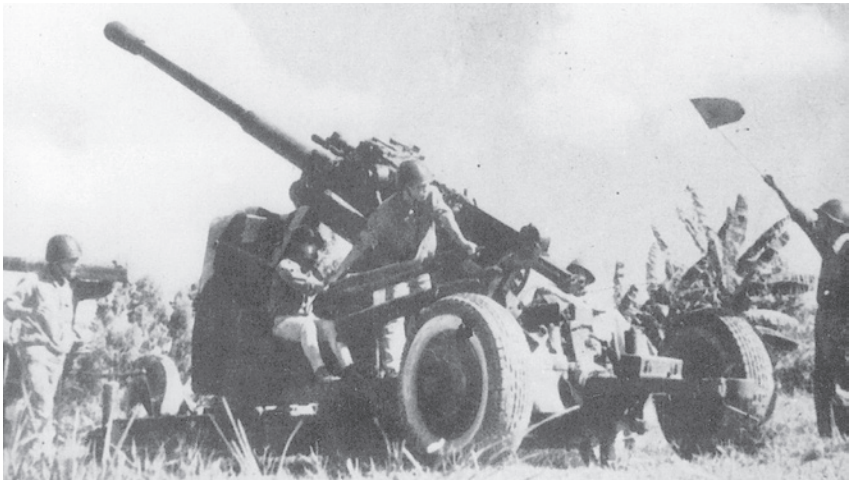
A-4F Specification	
Dimensions	
Length	40ft 3in. (excluding refueling boom)
Wingspan	27ft 6in.
Height	15ft 2in.
Wing area	260ft²
Weights	
Empty	9,624lbs
Max takeoff	24,500lbs
Performance (with one 300gal tank and 12 Mk 81 bombs)	
Max speed	550mph at 10,000ft (max speed clean 677mph at 3,500ft)
Time to 20,000ft	7.1 minutes
Combat ceiling	28,000ft
Combat radius	242 miles
Combat range	800 miles
Powerplant	One Pratt & Whitney J52-P-8A (9,300lb thrust) or J52-P-408 (11,200lb thrust) turbojet engine

COMMUNIST AAA WEAPONS

Although pilots could avoid the worst of the small-caliber fire by remaining above 3,500ft, they could not avoid the bigger 37mm, 57mm and 85mm guns, or the 100mm fixed sites in heavily defended areas.

North Vietnam's largest-caliber AAA weapon, the KS-19 100mm gun weighed 21,054lbs and measured 31ft in length, with an 18ft 8in. barrel. Its 15-man crew could generate a rate of fire of 15 rounds per minute, fired from a six-gun battery. On its mobile carriage base, the gun could traverse 360 degrees and elevate from -3 degrees to 85 degrees vertically. Fire control was by SON-9 or with the built-in PO-1M and PG telescopes. Each projectile was loaded manually into the semi-automatic sliding wedge-type breech.

The 85mm 52-K or M1939 originated in 1939. A heavy, towed weapon, it usually relied on the SON-9 "Fire Can" system for target guidance. On its carriage, the gun weighed 9,921lbs and required a crew of seven, loading single rounds. Its overall length was 23ft 2in. and the barrel was 15ft 5in. long. Like the KS-19, it traversed 360 degrees, and could be elevated to 82 degrees. In 1965 the fuses for 85mm rounds were set to detonate at 30,000ft, and US Navy pilots could fly above the black shell bursts with comparative immunity. Soviet advisers soon corrected this error.

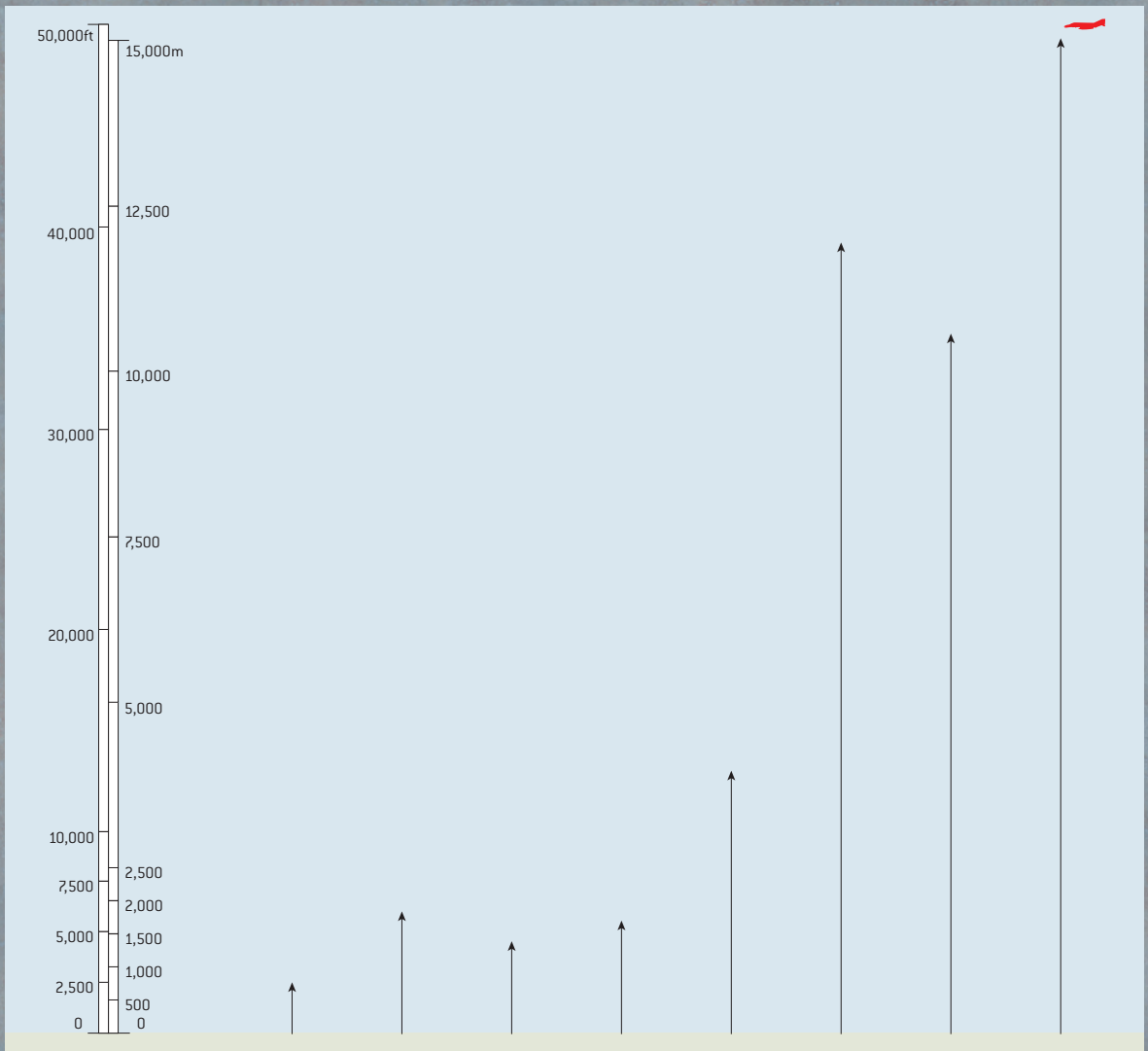


Seen during an actual engagement near Haiphong, the KS-19 100mm gun was North Vietnam's heaviest AAA weapon (Dr. István Toperczer Collection)

Introduced in 1950, the ubiquitous 57mm S-60 also used SON-9 and the PUAZO-5 or 6-60 fire director, or its own AXP-57 telescopic sight. On its travel carriage, it was 27ft 11in. long, with a 14ft 5in. barrel, and it also required a seven-man crew. Ammunition was loaded manually into the breech in four-round clips at the rate of one clip every eight seconds.

The M1939 (61-K) 37mm gun was one of the weapons most frequently encountered by A-4 pilots. Weighing 4,600lbs on its 19ft 9in. ZU-7 carriage, it could theoretically be fired while traveling but normally the wheels would be removed and each axle jacked up. The Type 65 was a Chinese copy of the Soviet export twin-barrel M1939, available from 1965.

The twin-barrel, gas-operated ZSU-23-2 was designed to engage low-flying targets at a distance of 1.5–2 miles. Weighing 2,094lbs and ten feet in length, this highly mobile weapon required a gunner and a commander to achieve rates of fire of up to 2,000 rounds per minute, although 400 rounds per minute was more usual. Its ZAP-23 optical-mechanical sight needed manually-entered target data for semi-automatic aiming. Ammunition was fed from 50-round boxes and the high rate of fire required barrels to be changed after a few hundred rounds, although their life was later extended to 10,000 rounds. Muzzle-flash suppressors made the gun more difficult to detect from the air. It was towed by four-wheel GAZ-66 or GAZ-69 light trucks, and together with the 37mm M1939, it was the most widely used North Vietnamese gun during the war. Four-barrel versions using the same 23mm 2A7 auto-cannon, water-cooled and mounted on a GM-575 tracked vehicle, became the ZSU-23-4 "Shilka," carrying far more ammunition and providing its own RPK-2 radar. The "Shilka's" withering 4,000 rounds per minute rate of fire, compared by an A-4 pilot to "a garden hose spraying bullets all over the sky," sometimes led to overheating and the spontaneous cooking-off of rounds. Fortunately for US forces "Shilka" were not available to the North Vietnamese until the final stages of the war in 1975.

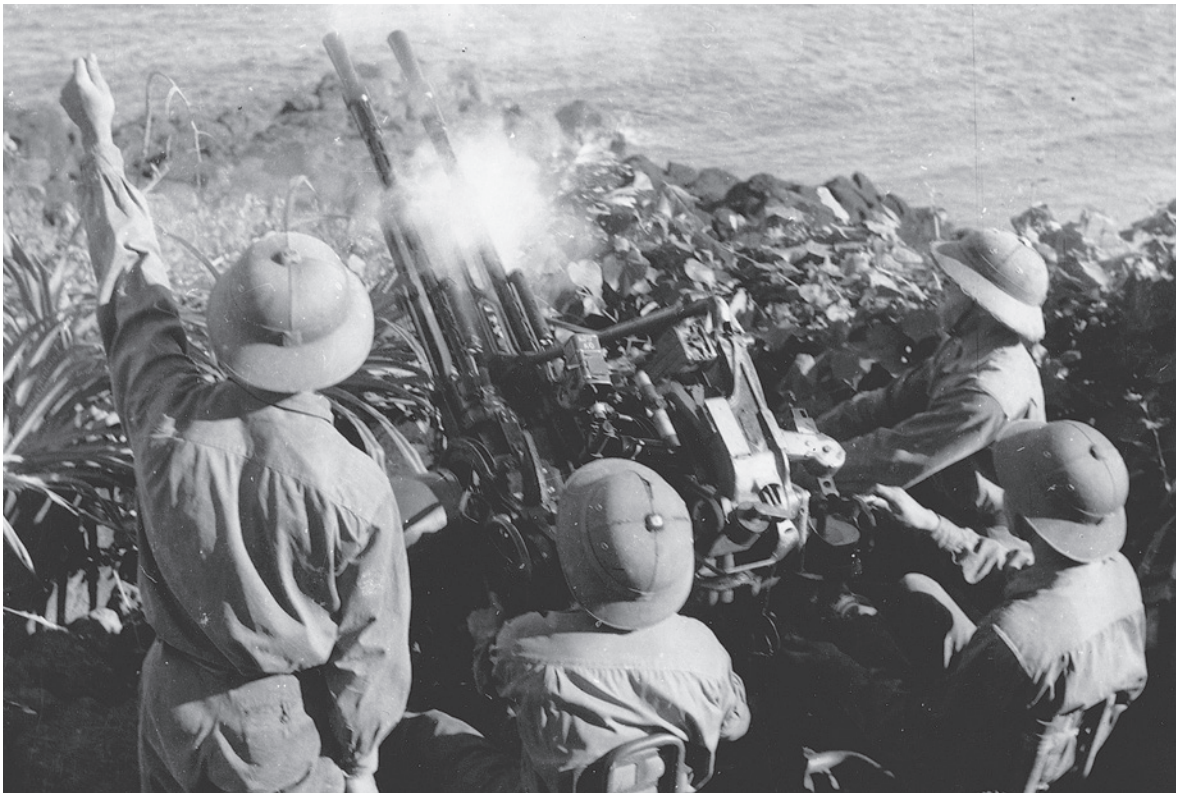


Type	67	DShKM	ZPU-2	ZSU-23-2	61-K	S-60	52-K	KS-19
Caliber (mm)	7-62	12-7	14-5	23	37	57	85	100
Rounds per minute	650	600	150	400	160	70	11	15
Effective altitude (ft)	2,500	6,000	4,593	5,500	13,000	39,270	34,448	49,213

North Vietnamese AAA altitude range diagram.

Twin- and four-barrelled versions of the 1950s-vintage ZPU 14.5mm gas-operated machine gun were also supplied, and the ZPU-4, with a crew of five and a four-wheel carriage, had a combined rate of fire approaching 2,200 rounds per minute from its air-cooled barrels. The single-barrel ZPU-1 version had a two-wheel carriage like the ZPU-2. The Type 58 was a Chinese ZPU copy.

Available to North Vietnam's militia in large numbers, the DShKM 12.7mm machine gun was a gas-operated 1938-vintage belt-fed weapon, mounted on a wheeled tripod or in light vehicles. Typical of the wide range of other light AAA weapons and small arms that proliferated in-theater, the Chinese Type 67 7.62mm machine gun was tripod mounted, with ammunition fed from belts containing up to 250 rounds. Weighing only 24.25lbs despite its 65in. length, the weapon was very portable and



A twin-barrelled ZPU-2 14.5mm gun team included a commander, a gunner and two ammunition loaders to sustain its 600 rounds per minute rate of fire. The weapon could be disassembled into components, each weighing about 175lbs, for manual transport through jungle or over mountain terrain.
(Dr. István Toperczer Collection)

could be used en masse to fire at low flyers from any location. Like other lighter weapons, the Type 67 could be avoided by flying above its range. Capt John Kuchinski recalled:

> Weapons like pistols, rifles and AK-47s were not effective above 3,000ft. The squadron's standard operating practice was to stay at above 3,000ft over North Vietnam. AAA could go much higher, so you had to keep a sharp eye out for flak at ingress and egress altitudes.

A-4 pilots hitting targets in South Vietnam tended to encounter the lighter, mobile AAA units, as Lt Col Bill Egen explained:

> Most of the time AAA consisted of 37mm and ZSU-23-4 type threats, along with an unbelievable amount of small arms fire. Based on fire incident [reports], South Vietnam far exceeded North Vietnam [in terms of enemy activity] on a daily basis, but this was because every Viet Cong or North Vietnamese soldier had a rifle, and helicopter crews were always reporting fire as well as fixed-wing pilots. We used to joke about getting bagged by a farmer who accidentally pulled the trigger while we were flying over.

Skyhawk pilots could identify the type of AAA that was targeting them by the color of the shell explosions. Capt John Kuchinski, who flew missions to relieve the siege of

The tradition of North Vietnamese women at war pre-dated the "American War." In Ben Tre province, there was an all-female Viet Cong company led by Thu Ha, famous for overrunning five government fortresses in the early 1960s. Women in field regiments had to be unmarried, but AAA troops in urban areas were often factory workers or students. This team in the 4th Military District awaits the flag to fire a coordinated burst from ZPU-1s, based on the Soviet 14.5mm KPV heavy machine gun. (Dr. István Toperczer Collection)

the US Marine Corps' Khe Sanh Combat Base in 1968, recalled that "37mm had a white smoke puff, while 57mm, 85mm and 100mm had black puffs. I don't remember seeing any 85mm or 100mm at Khe Sanh. It was either 37mm, 57mm or ZSU-23, a four-barrel weapon with a high rate of fire."

Name	Caliber	Max Altitude	Rate of fire	Projectile weight
Type 67	7.62mm	2,500ft	650rpm	-
DShKM	12.7mm	6,000ft	600rpm	-
ZPU-2	14.5mm	4,593ft	150rpm	2.12oz
ZSU-23-2	23mm	5,500ft	400rpm	6.27oz
61-K	37mm	13,000ft	160rpm	1lb 12oz
S60	57mm	39,270ft	70rpm	14lbs 8oz
52-K	85mm	34,448ft	10-12rpm	20lbs 5oz
KS-19	100mm	49,213ft	15rpm	35lbs

THE STRATEGIC SITUATION

The A4D-1 (A-4A from September 1962) was cleared for US Navy squadron use on October 26, 1956, and the 166 aircraft that were ordered shortly after the first flight, together with A4D-2s ordered in 1955, steadily entered service. The first deliveries were to VA-72, which had conducted Fleet Indoctrination Program tests for the Skyhawk. VA-94 converted next, and the first US Marine Corps A4D-1 unit was VMA-224 at MCAS El Toro, California. By August 1964, when the Gulf of Tonkin incident precipitated US involvement in the Vietnam War, the A-4 was the principal US Navy light strike aircraft.

Before Vietnam, US Navy carrier force activity tended to focus on the Mediterranean and Europe. Skyhawk pilots regularly practiced attacks on coastal "targets" in Spain and Portugal, approaching at 50ft above the sea to escape radar detection and the USAFE interceptors that awaited them. Pilots in US Marine Corps squadrons like VMA-332 received A-4Bs and practiced jet-assisted takeoffs (JATO) from pierced steel planking airstrips in exercises like Operation *Blue Star* in Taiwan in 1960. Their A-4 CAS operations from short airstrips with JATO were made possible through the employment of short airfield for tactical support (SATS) equipment, which facilitated arrested short landings – it was initially evaluated in 1962 at Quantico, Virginia, by four A-4Bs. SATS would be a vital mission facilitator for the US Marine Corps in Vietnam.

The North Vietnamese had vast experience when it came to anti-aircraft self-defense. While the French struggled to hold onto their colonial possessions in Southeast Asia in the late 1940s, the rebel Viet Minh and their military leader Gen Vo

NORTH VIETNAM
CHINA
BURMA
Dien Bien Phu
Hanoi
Haiphong
Gulf of Tonkin
PIRAZ Ship 3
Rescue helicopter ship
Barrel Roll (1965)
Mekong
LAOS
Thanh Hóa
Red Crown
Harbor Master
HAINAN ISLAND
Red Crown, Harbor Master and PIRAZ destroyers gave radar coverage of the Hanoi/Haiphong areas and provided protective MiG warnings and rescue cover for strike forces.
Vinh
Vientiane
Nakhon Phanom
Dong Hoi
Demilitarized zone
Hue
100 miles
Yankee Station
Steel Tiger
Danang
THAILAND
Chu Lai
Pleiku
Qui Nhon
Bangkok
CAMBODIA
CENTRAL HIGHLANDS
Gulf of Thailand
SOUTH VIETNAM
Cam Ranh Bay
Phnom Penh
Operation Menu
Bien Hoa
Tan Son Nhut
Saigon
Dixie Station
SOUTH CHINA SEA
Bases used by US Marine Corps A-4 units (Chu Lai was the main MAG-12 A-4 base)
N
0
100 miles
0
100km

US Navy Skyhawks, including these A-4Cs from VA-146 embarked in USS *Constellation* (CVA-64), were active in the South China Sea in August 1964 during the Gulf of Tonkin incident. CVA-64 was one of the first carriers to appear on *Yankee Station*, commencing its first line period on August 5, 1964 with USS *Ticonderoga* (CVA-14) – just a week after this photograph was taken of the two jets flying past the anti-submarine carrier USS *Kearsarge* (CVS-33). BuNo 149570 was lost in a mid-air collision with an RF-8A Crusader from VFP-63 Det F over the Gulf of Tonkin on November 13, 1964. (US Navy)

Nguyen Giap dealt with the problem of aerial re-supply of French forts in Vietnam and Laos by positioning AAA around them. French F8F-1 Bearcats began to fly flak suppression sorties, finding the camouflaged AAA sites hard to identify. In air strikes on Viet Minh troops at Dien Bien Phu, where France had established a base in November 1953, 45 out of 51 aircraft were hit by unexpectedly heavy AAA, with three being shot down. Giap had surreptitiously moved more than 13,000 troops into the area through almost impossible terrain. His 367th Regiment placed more than 100 AAA weapons, from 12.7mm DShKM machine guns to 37mm 61-K cannon, along the single valley approach to the airstrip.

Giap launched his assault on March 13, 1954, and the French hill forts fell quickly. Dien Bien Phu became a flak trap, with 48 aircraft being shot down, 14 destroyed on the runway and 167 receiving AAA damage of varying degrees, despite the re-supply missions being confined to the night. In desperation, the US briefly contemplated B-29 carpet-bombing of the Viet Minh positions. Losses of flak suppression aircraft mounted and the base was finally surrendered on May 7 after 2,293 French troops had been killed. A further 6,000 would die as prisoners.

Dien Bien Phu was the victory that gave Ho Chi Minh the confidence to tackle the Americans in a similar way ten years later. It was a vital training ground for North Vietnam's troops, including the AAA batteries. They learned that an unsophisticated force with outdated equipment could defeat a modern, well-equipped army with considerable air support. Clever tactics, ruthless determination and concentrated AAA weapons could apparently triumph, even though more than 23,000 Viet Minh were allegedly killed or wounded at Dien Bien Phu. However, many would bring their new-found skills to a different conflict in the 1960s and pass them on to a much larger civilian force which would operate guns in defense of North Vietnam.

NEW THREATS, NEW WEAPONS

In the 1950s, the emphasis on missiles in Western defense planning tended to sideline the gun in aerial combat and as a AAA weapon, despite at least 540 US Navy and US Marine Corps aircraft (more than 70 of them fast-moving jets) having been shot down by anti-aircraft guns during the Korean War. Barrage fire at an aircraft's predictable

OPPOSITE

TF *77* usually included two or three aircraft carriers in the *Yankee Station* area off Vietnam, although four were in place for peak operational periods such as *Rolling Thunder* or *Linebacker*. Two carriers conducted cyclical operations in either the northern or southern circles 100 miles northeast of Danang, undertaking air operations on a "12 hours on, 12 hours off" basis. *Dixie Station*, to the south, was used for incoming carrier air wings to work up to full operational capability over South Vietnam, before replacing a carrier in one of the *Yankee Station* circles off North Vietnam.

trajectory during a dive attack reduced the need for accurate aiming and negated evasive tactics by pilots. In Vietnam, the recommended 30-degree attack angle at low altitude put pilots at risk again, but from far more numerous AAA weapons. Early reconnaissance missions over Laos attracted AAA from jungle locations, and two US Navy aircraft were lost. Others fell during the *Pierce Arrow* (August 1964) and *Flaming Dart* (February 1965) raids, and by March 1965 US Navy loss rates were reaching an unprecedented 30 aircraft per 1,000 sorties. Only then was the effectiveness of North Vietnam's defenses truly appreciated.

The basic structure of North Vietnam's Artillery Branch was established long before hostilities began in earnest. In 1954 there were just 16 batteries of World War II-era German 88mm FlaK 18 guns in-theater, these weapons having been captured by the Soviet Union and passed on to North Vietnam. They were guided by Chinese-built copies of the *Würzburg* fire-direction gun-laying radar and supported by various light anti-aircraft weapons.

By 1957 the defenses had expanded to six AAA battalions, which combined with heavy machine gun units to form the 367th Anti-Aircraft Division. This controlled more than 7,500 troops equipped with 75mm, 90mm and 100mm AAA weapons and, from March 1959, two regiments with early Pegmantit-8 VHF radar units. In addition to the six divisions of the North Vietnamese Infantry Branch, it had 70 battalions comprising 100 batteries equipped with 1,000 artillery weapons. Its 1,700 mortars and recoilless rifles could also provide anti-aircraft small arms fire when required. Four brigades had 85mm, 122mm and 52mm howitzers. Throughout the fighting in Southeast Asia, North Vietnam was assisted by Soviet advisers and the estimated 320,000 Chinese troops and technicians who formed complete AAA divisions, among other wartime duties.

Initially, each AAA battery had up to six 37mm or 57mm pieces, and the older World War II-era 40mm, 85mm and 88mm weapons were gradually replaced by 57mm and 100mm guns from China and the Soviet Union. The newer weapons were concentrated around high-priority target areas, with the 292nd Regiment supplying radar facilities. At the end of 1963 the Anti-Aircraft Command and the Air Force Department (which was soon to receive MiG-17s) were combined into the Air Defense–Air Force Service Branch commanded by Snr Col Phung The Thai so that coordinated Soviet-style in-depth air defense could be organized.

A five-year plan from 1961–65 emphasized that more high-altitude anti-aircraft defenses were needed. In 1964 the North Vietnamese leadership duly requested Soviet SAMs, and the first Russian technicians arrived in January 1965 to begin constructing missile launch sites – a process that was accelerated by the commencement of Operation *Rolling Thunder* in March. In-depth defense evolved into a coordinated system around Hanoi and Haiphong in which SAMs and AAA could give priority to MiGs if required in certain areas, or MiGs could attempt to lure US aircraft into flak traps, all in carefully timed command sequences.

For pilots flying A-4s in hour-long Alpha strikes, North Vietnam's coordination of its defenses was "not a big issue for us to deal with" according to Capt John Kuchinski. "We came in every day, and all the air defense sites were ready and would shoot at you if you were in range. In 1967–68 I saw MiGs a few times, and our F-8 Crusaders would take care of them. Usually, MiGs stayed in the Hanoi, Haiphong and Thanh

Hoa areas. I did see an F-8 shoot down a MiG-21 with an AIM-9 Sidewinder near Vinh, but mostly they stayed farther north. We would see MiGs when we went after North Vietnam's airfields at Kep, Kien An and Phuc Yen, but the F-8s would deal with them."

In May 1965 the 236th Air Defense Missile Regiment, or "Song Da" Group, was established, commanded by Col Tsyganov, followed by the 238th Air Defense Missile Regiment, commanded by Col Bazhenov, in June. Using SA-2s and support equipment that had been secretly imported, both regiments were manned by the most experienced Soviet-trained troops then serving with the North Vietnamese Army (NVA). Furthermore, they would be "advised" by Soviet experts in-country. Training time was cut from a year to three months, with 37 different classes, and they were ready for action that summer. During 1965 American pilots noted a marked increase in the accuracy of AAA batteries (thanks in no small part to the work undertaken by the Soviet "advisers") and the appearance of "flak traps" around tempting targets to lure pilots into barrage fire.

US reconnaissance photographs taken over North Vietnam in 1964 revealed a steady increase in the number of Soviet-style AAA emplacements, like this complex with 57mm S-60 towed guns embedded in revetments. Sites that boasted 100mm guns usually fired these weapons in turn, typically in a clockwise pattern around the emplacement. The larger sites were visible to A-4 pilots from a distance of up to ten miles, which in turn left them vulnerable to dedicated flak suppression attacks. (USAF)

Although the Cuban Missile Crisis of October 1962 had spectacularly shown that SA-2s could destroy high-flying aircraft such as U-2s, AAA had still posed the greatest threat to the US aircraft that over-flew Cuba at lower altitudes. This situation would be replicated in Southeast Asia thanks to the rapid expansion of the North Vietnamese AAA force – it had grown from 12 to 21 regiments, totaling 41 battalions (eight of them mobile units), by the spring of 1965. The overall philosophy became one of "massed combined-arms forces" to defeat America's superior technology.

In early 1965 the North Vietnamese leadership came to the conclusion that more than half of the US air campaign to date had been aimed at disrupting the supply routes to "our brothers in the South" on the Ho Chi Minh trail. Sixty percent of North Vietnam's anti-aircraft defenses were assigned to protect these lines of supply and communication. AAA weapons were located inside bomb craters and close to bridges and ferry crossings, while an engineer regiment with 53 companies repaired bomb damage, defused unexploded ordnance and kept the convoys moving. "Troop stations" were established at various points along the routes, each with its own truck transport battalion, an engineer company, medical clinic, warehouses and AAA battalion. North Vietnam's tightly controlled and highly disciplined command structures remained in place as its forces moved into the unruly depths of the jungle.

Although constant reconnaissance and intelligence gathering was helpful in identifying AAA concentrations for the A-4 attackers, the mobility of the defenses made it impossible to give strike forces completely accurate briefings on the situation they would face. According to Vice Admiral Dunn:

VA-155 A-4E BuNo 150062 prepares to taxi to the catapult, laden with Mk 82s on the centerline and a 750lb M117 bomb (probably from USAF stocks) beneath each wing during *Coral Sea's* third war cruise in 1967–68. It was assigned to squadron XO Cdr Verlyne W. Daniels, who was downed by an SA-2 in BuNo 150059 and captured on October 26, 1967 during an attack on Phuc Yen airfield. BuNo 150062 eventually fell to ground fire during a CAS mission near Ben Het, in South Vietnam, while serving with VMA-311 on June 7, 1970. Capt Fredrick Palka ejected and was rescued by a US Army helicopter. (US Navy)

> We were not unduly concerned about the strength and location of flak sites. This was because there was flak pretty much everywhere. The routine was to have our jamming systems on and jink the aircraft virtually anytime we were over the beach. Where we knew flak was concentrated we avoided the area unless, of course, it was the target.

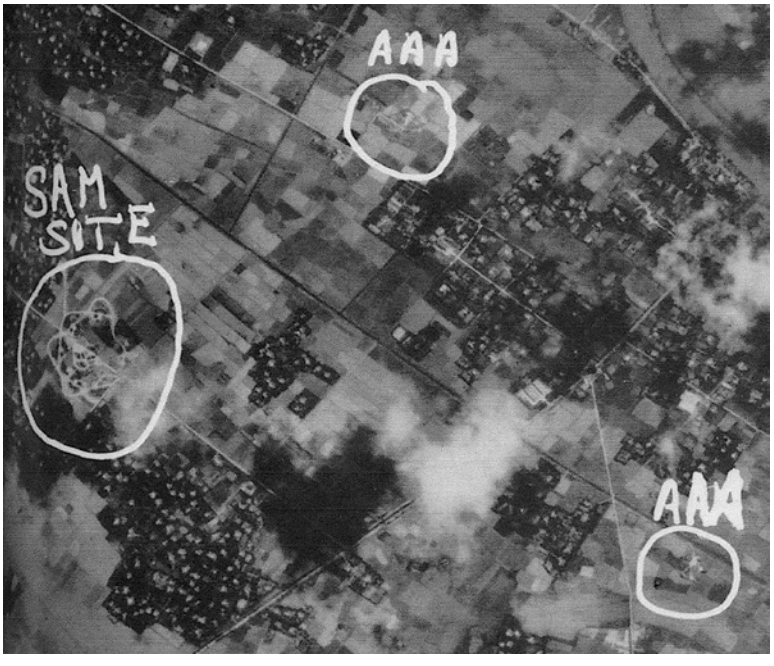
The US government's frequent "bombing pauses" gave the NVA every opportunity to re-arrange, repair and reinforce its defenses – a source of constant fury among the US forces whose lives were unnecessarily risked by such policies.

By April 1967 the North Vietnamese were enduring sustained US Navy air attacks on Haiphong, and it was clear that Hanoi would be subjected to similar strikes as President Lyndon Johnson's *Rolling Thunder* campaign finally targeted the capital city. The NVA's General Staff concentrated half the country's anti-aircraft regiments and all of its Vietnamese People's Air Force (VPAF) units on the defense of Hanoi. A massive mobilization effort organized farmers, students, civil servants and older children into cells equipped with infantry rifles and automatic weapons. Hundreds of AAA firing positions were set up in farmers' suburban fields, on rafts in Hanoi's Ho Tay Lake and around bridges. Although half of the capital's population was evacuated, those who remained were provided with thousands of air raid shelters, both communal and as individual shelter holes throughout the city. They were well-prepared when the US attacks on power stations in the outskirts of Hanoi began on April 25.

The shattered remains of an unidentified CVW-19 A-4 brought down by AAA over North Vietnam. Losses of US Navy Skyhawks increased from seven in 1964 to 77 in 1966, with small arms fire being responsible for the downing of many of these jets. (Dr. István Toperczer Collection)

By June 1967 Hanoi was protected by the 361st, 365th and 367th Air Defense Divisions. Ten AAA regiments, comprising 60 percent of

the country's anti-aircraft artillery, and five SAM regiments made up the heaviest air defenses ever committed to such a small area. The build-up continued until, by October, there were 14 AAA regiments with 1,000 guns and 26 SAM battalions with 156 launchers (80 percent of North Vietnam's missile force) sited around Hanoi.



SAM sites were always well-defended by AAA battalions, whose emplacements were less obvious from the air than the characteristic "flower" pattern of an SA-2 site. Other guns would be placed nearer the SAMs to catch low-flying attack aircraft while the heavier weapons would attempt to fend off *Iron Hand* A-4s. (USAF)

SPREADING THE NET

After the end of Operation *Rolling Thunder* on November 1, 1968, air attacks shifted south to North Vietnam's Military Region 4, the narrow panhandle of land between the Lam River in Nghe An province and the Gianh River in Quang Binh province comprising about a quarter of North Vietnam. Three Air Defense Divisions (the 367th, 377th and 368th) were sent to defend the supply routes in this area. The defensive forces farther north also continued to increase in size, and by 1971 its two million troops had 1,400 AAA weapons of all types. Workers at large factories were given 37mm guns to operate, and more militia platoons in rural villages were equipped with 12.7mm and 14.5mm guns to harass US aircraft. These well-trained militia and guerrilla platoons numbered 170 by mid-1972.

However, improvements in US weaponry, including the employment of stand-off bombs, laser-guided weapons and new missiles, together with more effective ECM, reduced loss rates to SAMs and radar-guided AAA. This period also saw increased use of the SAM and AAA battalions' mobility as they moved increasingly southwards into the lower regions of North Vietnam and neighboring Laos. Although US air operations had been significantly reduced by that stage in the war, the unexpected presence of air defenses in many areas previously devoid of them posed a threat to reconnaissance aircraft and their tactical strike escorts. Vinh was a particularly virulent AAA hotspot, and pilots were convinced that North Vietnam's AAA academy was located there. The many small islands within coastal waterways were also heavily fortified with guns to protect supply-carrying vessels.

When Operation *Linebacker I/II* returned large US Navy strike forces to North Vietnamese skies in support of the devastating 11-day B-52-led assault on Hanoi and Haiphong in 1972, there was another major reorganization of air defense resources, including the redeployment of the forward-based AAA regiments and the 274th Missile Regiment to Hanoi and Haiphong in support of the five AAA regiments that were already positioned around the capital. By then, however, US Navy light strike units had largely replaced their A-4 Skyhawks with A-7 Corsair IIs.

THE COMBATANTS

A-4 SKYHAWK PILOTS

As they prepared for Southeast Asian deployments, US Navy A-4 pilots had to shelve the nuclear delivery tactics that had been at the core of their training and re-learn simple World War II-style conventional bombing with no radar, a gunsight and pilot-computed lead. They also had to prepare for 18-hour working days, poor living conditions, stifling heat and incessant noise, particularly on the older aircraft carriers. Unlike USAF pilots, they were not restricted to a set maximum number of missions per tour of duty, and cruises could last up to ten months.

Before the two-seat TA-4F became available in 1966, pilots trained on single-seat Skyhawks after advanced training on TF-9J Cougars. They had to learn the "Scooter's" eccentricities, such as its stalky undercarriage and lack of nose-wheel steering. Movements on the flightdeck in an A-4B/C relied on guidance by "green shirt" deck crew with a tow-bar attached to the nose-gear. Turning sharply could jam the nose-wheel beyond 90 degrees, requiring a green-shirt to pull it out of the "stall."

Deck crew had rough jobs that put them dangerously close to "live" jets. One was knocking the thick, inflexible arresting cable loose from an aircraft's tailhook if it got stuck there when the pilot raised the latter, with moments to spare before the next aircraft landed. Index marks at the leading edge of the electrically trimmed tailplane of this A-4C from VA-93 showed its angle – a crucial factor when calculating a catapult launch. (US Navy)

After the deck crew had connected his aircraft (in this particular case, bombed-up A-4F BuNo 155065 of VA-153 on board *Coral Sea* in 1968) to the catapult shuttle, the pilot prepared for launch. His left hand rested on the throttle grip – a rod that prevented him from accidentally pulling back on the throttle under G force when the catapult fired. His other hand was positioned to grab the control column when G forced it backwards on launch. (US Navy)

Night carrier landings were described by former A-4E pilot Lt David Dollarhide as "always terrifying." The launch, on the other hand, was usually exhilarating, with acceleration to 140 knots in 2.3 seconds for a loaded A-4C on a 220ft catapult run. A properly trimmed Skyhawk, with its horizontal stabilizer at the correct angle and the catapult weight setting accurately entered, would do a hands-off launch. Once clear of the ship, the landing gear was stowed and flaps were raised in stages as the pilot climbed to 20,000ft to meet the other three members of his division. They would then proceed towards the target in "loose goose" formation, before attacking in "combat cruise" formation with around 120ft between the aircraft so that a single AAA hit could not damage two A-4s.

For a large Alpha strike on North Vietnam, the attack and escort squadrons launched their respective aircraft and assembled over the carrier, with units positioned at different altitudes. The fighter elements, with the thirstiest aircraft, would have already refueled from KA-3 Skywarriors by the time the attack aircraft had formed up, and the formation then headed for the coast at an altitude of around 14,000ft. For the lower-powered A-4B squadrons (only a handful of which saw combat in Vietnam), reaching such heights took time. F-4B MiG killer pilot Lt David Batson recalled that B-model Skyhawks typically reached their cruise altitude shortly before commencing the descent to attack their target! Fighters would weave gently behind the slower attack flights to maintain their optimum cruise speed, "jinking" harder as flak began to rise towards the strike force.

About 25 minutes from the "beach," after refueling, the A-4 pilots would set up their armament switches, test their ECM and turn on the master arm switch as they went "feet dry" over land. The emphasis then would be on accurate navigation and

A-4C SKYHAWK COCKPIT

1. Wheels and flaps panel
2. Friction lock control
3. Radio microphone switch
4. Speed-brake switch
5. Engine control panel
6. Radar control panel
7. Manual fuel shutoff control lever
8. Smoke abatement switch
9. Flap handle
10. Gunsight
11. Spoiler arm switch
12. Exterior lights master switch
13. JATO jettison switch
14. JATO arm switch
15. Approach compensator controls
16. Gunsight panel
17. Accelerometer
18. All attitude indicator
19. Radar scope
20. LABS timer
21. Clock
22. Oil pressure gauge
23. Engine performance indicator
24. Fuel quantity indicator
25. Radar altimeter
26. Fire warning light
27. AN/APQ-25(V)
28. Standby attitude indicator
29. Armament panel
30. Weapons release system panel
31. Bearing-Distance-Heading indicator
32. Vertical speed indicator
33. Angle-of-attack indicator
34. Altimeter
35. Caution panel ("Ladder Lights")
36. Airspeed indicator
37. Trim position indicator panel
38. Exterior light controls
39. Air conditioning controls
40. ASN-19A NAV computer controls
41. UHF controls
42. IFF radar control panel
43. ECM panel
44. TACAN panel
45. Interior lights panel
46. Rear-view mirrors
47. Rudder pedals
48. Control column
49. Throttle control
50. Pilot's seat
51. Ejection handle
52. Angle of attack indexer
53. Cockpit ventilation
54. Cockpit lights
55. Arresting hook control
56. Emergency generator release handle
57. Landing gear control
58. Emergency landing gear release handle
59. Emergency bomb release handle
60. Manual flight control handle
61. Catapult hand grip

looking out for AAA and SAMs. Approach to the target was at around 12,000ft. Shrike missile-armed *Iron Hand* A-4E SAM killers went to work and flak suppression fighters or A-4 sections accelerated ahead of the formation to drop ordnance on known AAA sites. Their bombs usually had variable-time (VT) fuses that detonated the ordnance over flak sites just as the attack sections rolled in on their targets. Pulling out from their 45-degree attack dives at about 4g, the strikers then re-formed in sections (pairs) and headed for the coast to check each other's aircraft for AAA damage. For coastal targets like Thanh Hoa or Nam Dinh, the aircraft would be over land for only five to eight minutes, but deeper targets like Phuc Yen or Hanoi involved over-land flights of around 30 minutes.

An A-3B from VAH-8 services bomb-laden A-4Es of VA-23 heading toward North Vietnam in 1965. The squadrons were from CVW-2, embarked in *Midway* – both the air wing and the carrier were undertaking their first combat cruise. VA-23 lost three Skyhawks in combat during the deployment. (US Navy)

The US Navy quickly realized that the key to mission success with minimal losses in North Vietnam was the effective execution of *Iron Hand* tactics over the target area. Training pilots for this role assumed great importance, and there was never a shortage of volunteers for this crucial but extremely hazardous task. As Capt John Kuchinski explained, there was "special training for pilots of Shrike-equipped aircraft, but that was because we had so few Shrikes to shoot, so they were saved for the most important targets. Flak suppression was not a specialty as any A-4 could carry the ordnance for that, and all A-4 pilots were trained in flak suppression. [Weapons training in the USA concentrated mainly on] bombing accuracy on a raked target. On the last day of a weapons [training] detachment we would have a practice Alpha Strike on targets on a range at Nellis AFB. The USAF would attack our 40-plane strike group with F-4 Phantom IIs and T-38 Talons and we would try to get through the 'furball' to drop on the assigned targets."

Iron Hand and flak suppression were two separate missions, as Capt Denny Sapp emphasized:

> *Iron Hand* would detach from the strike group prior to feet dry [crossing the coast] to ingress the target area. They would stay over the designated SAM area until the Alpha strike was completed and had gone back feet wet. Their primary targets were SAM radars. Shrike frequency fusing was programmed for those radars, but it could also be programmed for other radars, although it was not switchable from the cockpit. Flak suppressors would detach from the Alpha strike group a minute or so ahead of the strike's roll in [to bomb] in order to take out the AAA sites surrounding the main strike target.

Iron Hand preparation was largely confined to listening to a variety of tapes recorded by ECM aircraft so that pilots could recognize the radar emissions of "Fire Can" AAA and "Fan Song" SAM transmitters, followed by on-the-job training when

Oriskany plows through the South China Sea, its flightdeck crowded with aircraft from CVW-16. A-1s take up the aft portion, while A-4s share space with F-8s. An A-4 rests on the bow elevator aft of the "34" hull number. The carrier and CVW-16 conducted three combat deployments between April 1965 and January 1968, during which time the air wing lost 60 aircraft to AAA, SAMs and MiGs. No fewer than 29 of the aircraft destroyed were A-4s. (US Navy)

they arrived in-theater. Visual detection was used in around half the sightings of missile sites by *Iron Hand* pilots and the rest were identified electronically. A typical A-4E squadron like VA-192 had six *Iron Hand*-trained pilots.

When it came to avoiding AAA, Vice Admiral Dunn recalled that, as a cruise began, "there was no specific guidance with regard to work-up indoctrination on flak. The general instruction was to keep jinking left and right, up and down and keep the ECM turned on. There was no flak to speak of in South Vietnam – the area where we would fly when on *Dixie Station* [before moving north to *Yankee Station* off North Vietnam] – unless one went low; a temptation in a low-threat area. Small arms would be almost sure to get you then." As for barrage flak, "I recall no specific instruction. In fact I'm not sure I would have known it if it came at me. There was 'no flak' (we lied to ourselves – there was always flak over North Vietnam), 'light flak' and 'heavy flak'. I guess it was barrage flak when you were flying through the gray puffs. In any case, you just kept jinking, kept your ECM on, checked on your wingman or leader and kept pressing on towards the target." On *Dixie Station*, attack squadrons usually flew up to 20 missions before moving north.

In Capt John Kuchinski's opinion, "Jinking was effective, but you needed to be able to see the fire coming up to know which way to jink. If we could see the AAA coming up at us we could maneuver to avoid getting hit most of the time. I think most guys who got hit by AAA had it happen on roll-in or while on the 45-degree bombing run, or even after weapons release and pull-out [to level flight]. We [VA-94] had an ethos that we would not break off a bomb run because of flak or SAMs. So, we would jink while going to the roll-in point, but make a good bomb run and drop regardless of the flak, then jink and maneuver hard on egress to avoid AAA and SAMs." US Navy pilots tended to break to the left when they pulled up off the target, so breaking in the other direction could fool the gunners for a few vital seconds.

Allocation of pilots to defense suppression duties depended to some extent on the composition of the A-4 squadrons in an air wing, as Vice Admiral Dunn explained. "We had both the A-4C [VA-146] and A-4E in our air wing [CVW-14, embarked in USS *Ranger* (CVA-61) in 1965–66]. Because the A-4Es had the extra ordnance stations, they got the *Iron Hand* missions. Thus, VA-146 benefited by not having that exposure." Indeed, VA-55 lost eight Skyhawks in combat during that cruise while VA-146 had just two jets shot down. *Ticonderoga*'s CVW-19 often flew an F-8E with each *Iron Hand* A-4E to watch out for AAA and SAMs, as the Skyhawk pilot would be "head down" in the cockpit focused on his SAM detection instruments.

As the war progressed F-4 Phantom IIs were increasingly used in flak suppression flights. "Flak suppression did not require specialists, but on a large strike we would use the Phantoms in that role," Vice Admiral Dunn recalled. "As we neared the target they would accelerate ahead and roll in just before we did, releasing two VT-fused [delayed action] 500lb bombs high and two more at lower altitude. That, theoretically, caused the gunners to duck their heads and gave the A-4 bombers a chance for a precision delivery."

Hitting back at the guns was a powerful temptation for any pilot, but experienced Naval Aviators learned to resist it. VA-163's Cdr Harry Jenkins decided to take out two weapons, against the advice of his Korean war-veteran wingman, during a strike on Ha Tinh barracks in 1965. While his wingman devastated one of two apparently inert gun sites, Jenkins lined up for his strafing pass, only for his jet to be hit hard by a third unseen battery. Although a large-caliber shell blew off his canopy and destroyed his instrument panel, Jenkins somehow managed to trap back aboard *Oriskany*.

Lt(jg) John Kuchinski of VA-94 peers purposefully from the cockpit of an A-4E chained to the flightdeck of *Bon Homme Richard* on *Yankee Station* in 1968. His squadron did not lose a single jet during this particular cruise with CVW-5. Conversely, sister-squadrons VA-93 and VA-212 (both equipped with brand new A-4Fs) suffered six combat losses between them, plus three in operational accidents. (US Navy)

NVA GUNNERS

A Defense Intelligence Agency report in November 1965 attributed half of US air losses and most of the aircraft damage to automatic weapons of 14.5mm caliber or smaller, with the DShKM 12.7mm machine gun proving to be particularly effective. The report stated that gunners, organized into "firing cells," were trained to fire small arms at any aircraft that was within estimated range, regardless of its speed, until the aircraft was out of sight. A platoon-sized firing cell could, therefore, fill the air with up to 1,000 rounds within five seconds. Although this approach put civilians at risk from stray and falling spent rounds, it presented low-flying pilots with an almost impenetrable wall of bullets. They were forced to stay above 3,500ft and spread their sections, with at least 3,000ft between aircraft.

Night attacks on the trails network required coordination of the available AAA protection by radio signals or whistles. Gunners would also look out for the flashes from ejector cartridges in the A-4's weapons pylons as bombs were released.

Larger-bore weapons could be used for barrage fire, with 37mm or 57mm shells fused to detonate at pre-set altitudes and trajectories around tempting "flak trap" targets such as bridges or SAM sites. In 1965 more than half of the NVA's 57mm and 85mm guns were positioned within 30 miles of Hanoi and Haiphong, with the rest surrounding crucial centers such as Thai Nguyen, Thanh Hoa and Vinh. Residents became adept at diving into the many air raid shelters and one-person pits with manhole covers, and they would remain there until all the AAA shell and missile debris

North Vietnam's revered leader Ho Chi Minh with a 57mm S-60 crew from the 6th Company of the Tam Dao Regiment, charged with defending Phuc Yen air base, on September 25, 1966. Despite failing health, he continued to inspire the defenders. He would touch the seat on an AAA gun to see whether it was warm from recent use, urging the gunners to avoid wasting ammunition and coordinate a six-gun battery to fire at one aircraft until it was brought down. (Dr. István Toperczer Collection)

had fallen back to earth. Gun crews, however, quickly gained a reputation for remarkable courage, staying at their posts during the most devastating of air attacks. Stories began to circulate among US troops that gunners were chained to their weapons. Losses were undoubtedly heavy, but replacement crews and weapons were readily available.

In March 1964 the Air Defense Branch had moved from peacetime to wartime status and thousands of militia self-defense anti-aircraft cells were established, many of them equipped with 12.7mm guns. Bomb shelters were constructed, crucial facilities were fortified and there was general training in fire-fighting and casualty evacuation. North Vietnam was a country well used to war, and in 1964 it was preparing very thoroughly for a prolonged conflict with the USA, even to the extent of containing an invasion. Some militia sought expertise in "surrounding and capturing enemy commando forces" under the direction of "Uncle Ho."

North Vietnam showed considerable determination in organizing its local defenses within a comprehensive national effort. In 1964–65 its anti-aircraft battalions used numerous recruits from China, many of them veterans of the Korean War with experience of shooting at US jets. They taught their volunteer gun crews, numbering from three to seven operators and loaders, the importance of discipline and coordination in maintaining their weapons and sustaining high rates of fire. By 1971 Hanoi estimated that it had two million self-defense troops available. They possessed 50,000 infantry weapons and 1,400 anti-aircraft guns. The larger factories had self-defense battalions with 61-K 37mm guns, while local village communities manned DShKM and ZPU-2 weapons. Local militia in some coastal villages were equipped with 85mm 52-K anti-aircraft guns that they could also use against US Navy ships that moved closer inshore in order to shell a variety of targets.

At all levels, training was a top priority, and military indoctrination (heavily politicized) was conducted regularly at high schools, universities and trade apprentice schools. Recruits learned the importance of sector fire in which numerous guns were aimed at a predetermined area of airspace to fill it with lethal explosions just as US aircraft passed through. Using all the available types of gun in a heavily defended area simultaneously, it became possible to compute how much ammunition was required to fill a column of air with shrapnel at altitudes from 1,000–30,000ft or more. The coordination of batteries was practiced constantly, and visitors to North Vietnam were impressed by the way in which batteries across a whole target area would start and finish firing simultaneously. Training concentrated increasingly on firing at high-speed jet aircraft well before any appeared over North Vietnam's cities.

When attacks began, the gunners had most difficulty in dealing with low-flying aircraft without resorting to barrage fire or multiple small arms. Fuses were usually set for shells to arm and explode at higher altitudes. On a SAM site strike by A-4s from

CVW-16 on August 23, 1965, two were hit by 57mm rounds as they attacked at an altitude of less than 100ft. The shells went clean through both aircraft (passing through the engine of Lt(jg) Charlie Stender's A-4E from VA-163) without arming, and both pilots were able to get home.

Many specialized training programs were set up for AAA gunners, and Hanoi University devised scientific tables showing the ideal location of each gun to enable concentrated fire around key targets. At the same time SAM troops attended training sessions on coordinating their missile launches with the guns and ground-controlled interceptions by MiGs. Air defense units were reorganized into five divisions – the 361st, 363rd, 365th and 369th Strategic Area Defense Divisions – each with up to six AAA regiments operating 57mm and 100mm guns, and the 367th Mobile Air Defense Division with four AAA regiments and one missile regiment.

To test the flexibility of this arrangement, three AAA regiments and three with missiles undertook a mobile combat operation to the Thai Nguyen area, north of Hanoi, in July 1966 to oppose intensive US air attacks. Another mobile operation by the 367th Division to cover Route 1 around Thanh Hoa in September 1966 resulted in 668 AAA engagements and 56 with missiles within one month. Although the division claimed the destruction of 24 aircraft, only two US Navy jets were officially lost in that area during September. One was A-4C BuNo 148488 of VA-22 from USS *Coral Sea* (CVA-43), hit by an SA-2 on the 17th. Its pilot, Lt(jg) R. A. Hegstrom, was recovered.

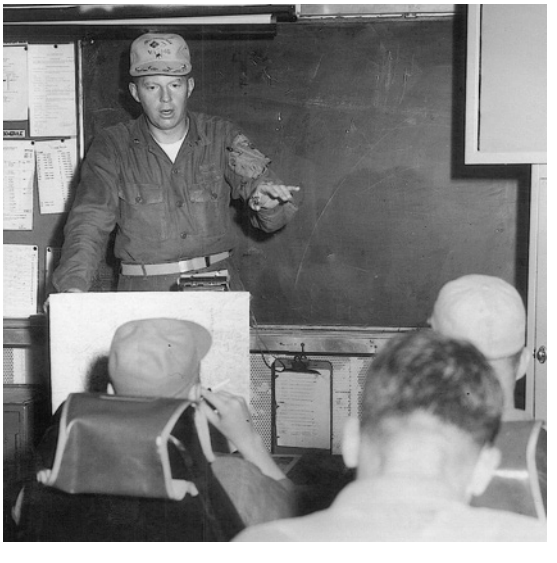
There was also increased emphasis in 1966 on strengthening coastal AAA defenses and arming local militia in the hope of catching US Navy aircraft on low-altitude entry and egress. Low-flying A-4s on road reconnaissance missions against targets of opportunity were hard to catch but, as Vice Admiral Dunn recalled, AAA crews could hope that the aircraft might break the "one pass, haul ass" rule for attacking well-defended targets and return at a point where the gunners would be ready for them. "Road recce invariably surprised the targets we found, and the initial detection undoubtedly alerted any AAA in the vicinity, but the 'one pass' rule held, and it was probably more important there than against fixed targets. AAA around fixed targets would have been diminished during the initial attacks."

ABOVE LEFT
Members of the eight-man crew of this M1939 (61-K) gun hold five-round clips of 37mm ammunition, ready to feed them vertically into its rising/sliding block breech, with an average re-loading time of two seconds. One soldier (top right) is aiming the gun with its AZP-37 optical sight – the latter confined the weapon to daylight use only. (Dr. István Toperczer Collection)

ABOVE RIGHT
Training AAA gun crews involved simplistic models to simulate A-4 formations at a distance, combined with real gunsights. (Dr. István Toperczer Collection)

COMBAT

Cdr Bob Dunn briefs his VA-146 pilots before a mission. Dunn received two Silver Stars during his tours in Vietnam and eventually commanded the carrier USS *Saratoga* (CV-60). Achieving flag rank, he was Commander Naval Air Forces Atlantic during operations against Libya in 1986. As Deputy Chief of Naval Operations (Air), at age 58, he made one more carrier landing in a single-seat F/A-18 just before retiring. (US Navy)



You approach North Vietnam from out of the southeast, from *Yankee Station* out in the Gulf of Tonkin. The coastline looms dull and flat through the haze. Huge gray streams looking like rivers of silver flow toward the sea from the southwest. Rice fields filled with placid black water spread from the meandering rivers. In the far distance, silhouettes and shadows of mountains rise up. To the right sprawls Haiphong, its waterfront crowded with fat freighters. Dead ahead lies Hanoi. Closer at hand, just off to the right, should be our target. Crossing the coast line, the adrenaline begins to surge and the jinking begins. The fighter flak suppressors move ahead. Now, you double check your navigation, check on your wingman, check your armament switches. All set. We press on.

Suddenly one of the fighters calls, "Flak at 'ten o'clock!" Checking left, you see it's not too bad. Just a few puffs slightly low – no sweat. Then another call, "Missile lifting at 'two-thirty,' just by the bend in the river." You're lucky. You see this one lifting off – first a cloud of dust at the launch point, then a long orange flame rising ever-so-slowly up and toward the force. Pulling hard, you look for launches two and three. Seldom do they fire single missiles. The missiles pass clear, exploding astern in great orange puffs. A section of the strike group is ordered to detach and hit the launch site.

Meanwhile, the target area is alive with black puffs, white puffs and sparklers; muzzle flashes from what seems like hundreds of guns. As we get closer, the flak begins in earnest. It's so thick that you feel your plane is being bounced around

by detonating shells. There's really only one thing to do – roll in on the target.

This was how Vice Admiral Robert Dunn, commanding VA-146 embarked in USS *Constellation* (CVA-64) in 1967, described what he called a "routine strike." Throughout most of *Rolling Thunder* such missions were a twice-daily occurrence for the air wings of TF 77. By then, A-4 units had been dueling with North Vietnam's AAA defenses for almost three years. The first such clash had occurred on August 6, 1964 during the US Navy's initial punitive raid – codenamed Operation *Pierce Arrow* – on North Vietnam in response to the Gulf of Tonkin incident three days previously.

The 12.7mm DShK-38 gas-operated machine gun was used in considerable numbers, the weapon being capable of firing 50-round belts at a rate of 600 rounds per minute against low-flying aircraft. A crude iron sight was used for aiming, and its comparatively light weight (346lbs, including the wheeled tripod) meant that it could be set up quickly in any environment. (Dr. István Toperczer Collection)

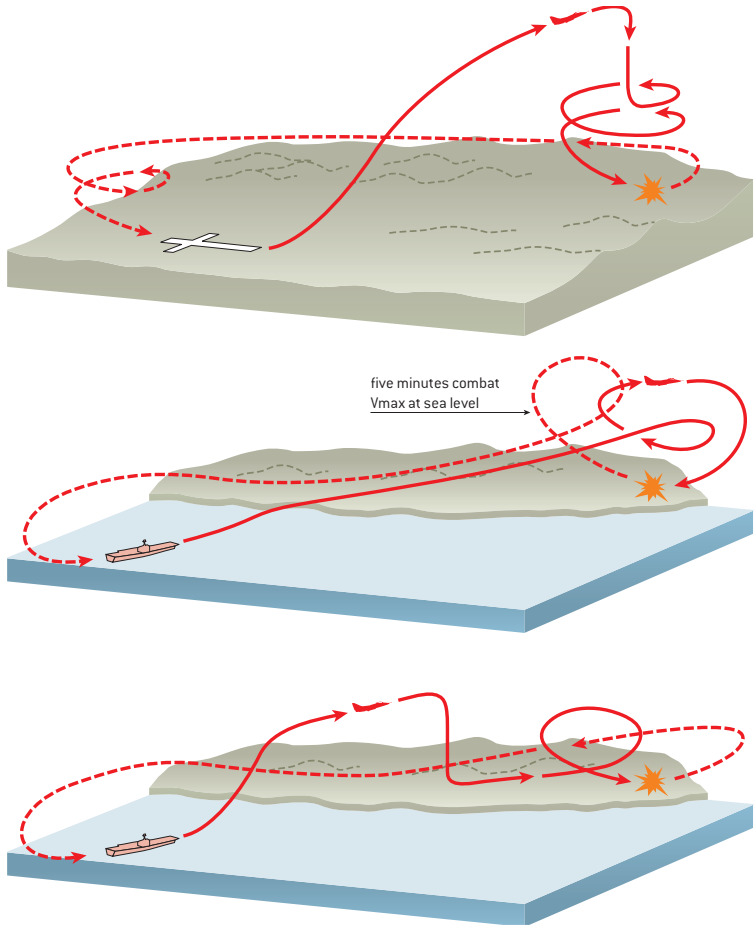
Constellation's CVW-14 launched ten A-4Cs and 14 A-1H Skyraiders, with five F-4Bs as top cover, for attacks on the naval bases at Hon Gay and Loc Chao. It was believed that North Vietnamese torpedo boats that had mounted attacks on the destroyer USS *Maddox* (DD-731) had originated from these sites. CVW-5 dispatched another force from *Ticonderoga*, and although 25 boats were destroyed, the element of surprise was lost when President Johnson gave advanced warning of the attack.

Lt(jg) Everett Alvarez of VA-144, flying A-4C BuNo 149578 from CVA-64, had to fly through fog and heavy AAA from the well-prepared batteries surrounding the bases. His aircraft was hit and he was forced to eject, duly becoming the first US airman to languish in a North Vietnamese prison – he would spend eight-and-a-half years in jail. Some of Alvarez's colleagues, except for the Korean War veterans, were shocked that a modern jet could be shot down by old-fashioned guns.

Skyhawks were the US Navy's main strike aircraft when hostilities in Southeast Asia began to increase in their intensity in 1964, and the A-4 remained in frontline service into the early 1970s, despite being partially replaced by the A-7 Corsair II from November 1967. For the US Marine Corps, the Skyhawk was its principal light strike platform throughout the war in Vietnam.

The A-4 proved to be capable of absorbing considerable damage. Aircraft returned to base with up to three of the shear web beams in their wings severed, and in one case a jet survived a 4g pull-up with that amount of damage. Its survivability quickly became legendary. Early in the war an A-4 made a 230-mile return journey after being hit by four rounds 37mm. The thick cockpit skins, rather than the light skins on the heavier fuselage frames, gave pilots protection against small arms fire. That structural strength saw the Skyhawk through many demanding situations. On March 5, 1966 a pilot flew an A-4C into clear-air turbulence near Mount Fuji in Japan that had torn a BOAC Boeing 707 airliner apart just hours earlier, killing all 124 passengers and crew. The A-4C survived forces of +9G and -4G in the process and the pilot was severely battered, but both returned safely.

The top diagram shows a typical US Marine Corps CAS mission profile. The A-4 had a combat radius of 615 miles with one 1,000lb bomb on the centerline pylon, two 500lb bombs on the outer wing pylons and two 300-gallon drop tanks. Given air superiority over the target area, this fuel load allowed for 45 minutes' loiter time near the target at an altitude of 5,000ft. With the same fuel and weapons load as in the depicted CAS mission profile, a carrier-based A-4 could strike within a 400-mile combat radius, approaching, attacking and exiting at low altitude, and allowing for five minutes of aerial combat at full power and at sea level. Finally, given the same fuel and ordnance load as seen in the previous diagrams, but using a "hi-lo-lo" profile, the tactical radius could be extended to 545 miles. The final 60-mile dash to the target could be flown at very low altitude and at full power. Egress to the carrier would also be at low altitude.



FLAK SUPPRESSION AND *IRON HAND*

For the early years of the war flak suppression for naval air strikes was usually provided by F-8 Crusaders from Essex-class aircraft carriers like *Hancock* and *Bon Homme Richard*. They dived on flak sites at 45 degrees, releasing Zunis and 1,000lb bombs at 4,500ft and following up with 400 rounds of 20mm cannon fire in a single attack, with a pull-out in afterburner at 3,000ft. When larger carrier air wings began attacks in Alpha strikes after June 1966, similar tactics were used, but the number of flak suppressors was increased and A-4s undertook this hazardous role instead.

Flak suppression and *Iron Hand* were the most demanding missions A-4 units had to fly in Southeast Asia, and both required pilots to head directly at the enemy's very heavy defenses to try and defeat them. Capt John Kuchinski defined the two roles as follows:

> *Iron Hand* was strictly an SA-2 "Guideline" kill/suppression mission, usually in support of an Alpha strike against an important target using a single A-4 with two or more Shrikes. This A-4 would be chased by a second A-4 to help with lookout and, for safety reasons, in case the Shrike bird was hit. It might also carry Shrikes in case the first aircraft had a problem. The Shrike aircraft was equipped to attack a "Fan Song" radar van and the pilot had special training to fly a "loft" maneuver to deliver the missile. It would

not fly in the main strike group, positioning itself elsewhere in an optimal location to attack any "Fan Songs" that would light off and threaten the strike group.

Our sister squadron [VA-93] got all the *Iron Hand* missions and my squadron [VA-94] would be assigned flak suppression or be part of the main strike group. I don't remember *Iron Hand* ever going after AAA "Fire Can" radars. Flak suppression missions went in to attack AAA sites in the target area, although I can remember going after a SAM site once with bombs and rockets because it fired an SA-2 and was a threat to the strike group. Flak suppression aircraft could be loaded with CBUs, 2.75in. rockets or Mk 82 bombs fused to airburst over AAA sites. They would detach from the main strike group and fly in ahead to attack AAA defenses first so that there was likely to be less flak for the bombers to contend with as they attacked the main target. Flak suppression could be a little scary as you would see the streams of AAA rounds flying past your canopy. They looked like hundreds of little balls of fire going by your head. I can remember seeing AAA site muzzle flashes through the smoke of bombs dropped from other aircraft.

Some pilots reported being able to hear the detonations of AAA shells exploding close to their aircraft.

One of the main problems facing flak suppressors was the unpredictability of the sites' location, although reconnaissance could usually pinpoint batteries for briefing purposes. However, as John Kuchinski pointed out, "The sites moved a lot, and sometimes predictions on active AAA were not that good. You might get flak from a site one day but not the next. You could avoid known sites [on entry and egress routes and around targets], but if that was not an option, the location of flak batteries would not keep you from attacking an assigned target. You just had to fly through the flak."

Attacks on gun sites were inevitably hazardous, and they could include shore batteries that threatened Seventh Fleet vessels and rescue attempts of downed aviators by naval helicopters. *Ticonderoga* launched five VA-56 A-4Es on February 7, 1966 to attack a coastal artillery site that had fired at a US Navy destroyer. The A-4Es hit the site with 500lb bombs, destroying one gun despite fearsome opposition from small arms fire. Further attacks were deterred by bad weather, so the flight turned south along Route 1 in search of targets of opportunity.

The mission leader, Lt Cdr Render Crayton, who had flown some of the first *Flaming Dart* retaliatory strikes following the Gulf of Tonkin incident, had noticed railway trucks in a siding near Phu Dien Chau and he began a dive attack. Immediately, 37mm fire opened up on the Skyhawks from well-camouflaged sites, and shrapnel from one of the exploding shells struck the starboard side of Crayton's A-4 (BuNo 152027), damaging the engine and hydraulic system. He headed for the coast but the Skyhawk's controls soon froze and the aircraft rolled inverted. Section leader Lt Ed Pfeiffer saw the A-4E crash, and he also noticed Crayton's parachute drifting down and orbited to set up a rescue. A helicopter from an offshore destroyer and two A-1 Skyraiders headed for the survivor while Pfeiffer strafed and bombed groups of North Vietnamese who were closing in on Crayton by land and sea.

The A-1s arrived and joined in the protective effort but the helicopter had apparently headed to the wrong point. As more enemy troops arrived and headed for Crayton, who was weakened by a broken arm, Pfeiffer and his wingman made repeated passes over them until the helicopter finally appeared. By then the small arms fire was too

A division of A-4Es successfully attack the Phuong Dinh Bridge in 1967. Two aircraft can just be seen at low altitude (bottom right) and another is pulling out of its dive to the left of the bridge. A heavy AAA site is visible (top left) close to the Doppler fairing under the nose of the camera-carrying Skyhawk. A second site can be seen close to the river bank (bottom left). (US Navy)

concentrated and it was hit repeatedly and forced to retreat. The Skyhawks, very low on fuel, had to withdraw too, and Crayton was captured and taken to Son Tay camp. Remaining incarcerated until February 12, 1973, Crayton received the Silver Star upon his release for his actions on the February 7, 1966 mission.

Heavy attacks on AAA positions were sometimes called in to suppress ground fire when rescue missions for pilots were underway. An attempt to recover A-4E pilot Lt Cdr Richard Hartmann from VA-164 on July 18, 1967 included bombing runs and Zuni attacks on the many AAA sites in the area where he had ejected (from BuNo 151986), which was just 25 miles from Hanoi. Sadly, the unsuccessful effort cost two more A-4Es (both pilots rescued) and an SH-3A rescue helicopter (all four crew killed) to ground fire – Hartmann also perished while in captivity. This type of flak suppression, although effective on many occasions in enabling rescues, was fraught with danger, as Vice Admiral Dunn emphasized:

> Dueling with the AAA sites was always a no-no. Assigned flak suppressors would go in against them but that was the extent of it. The 37mm was probably the most formidable because it had a rapid rate of fire, it was the most widespread and the most difficult to see. On the other hand, we could see the gray and black puffs of the detonations on the larger calibers. The scariest I ever saw was 23mm at dusk. The rate of fire was so high that the tracers seemed to merge into one long stream, almost like a garden hose aimed at you. In reality the 23mm wasn't all that much of a threat because it was not effective at the altitudes we usually flew at, and one could easily see the stream of bullets and where it was pointed.

From a pilot's viewpoint, barrage AAA in such volumes made attempts at evasive maneuvering or "jinking" irrelevant, although most pilots tended to jink as much as possible while at the same time keeping their eyes on the target. However, with no other means of self-defense available to them, pilots could only, in Vice Admiral Dunn's words, "stay high until close to the target and weave and jink continuously while over land."

VA-55, embarked in *Constellation* in 1967, used a flak suppression tactic that saw a lone A-4C fly over a known AAA site at low altitude to try and draw fire while a second aircraft held off at higher altitude, ready to dive and attack the site with bombs and Zunis. For lower-caliber guns like a ZSU-23, Zunis were more appropriate than bombs, as their range was greater than the effective reach of the 23mm shells.

THE GUNS

John Colvin, who was Consul-General at the British Embassy in Hanoi during *Rolling Thunder*, noted that "every bush concealed an anti-aircraft weapon" and that all the roads were lined with anti-aircraft guns. Residents, including foreign diplomats, were required to hide in cylindrical holes with concrete lids in the city's pavements, and air raid sirens would sound up to 30 times a day.

Frequent complaints from the Soviet Union about North Vietnam's profligate expenditure of its costly SA-2 missiles apparently did not apply to the tons of AAA ammunition fired aloft during every US attack. Colvin described a low-altitude by F-105s on a Hanoi power station that marked the beginning of the attacks on the central "circle" Hanoi targets in 1967, and noted the frustrated fury of AAA crews who had opened fire when the Thunderchiefs were already 20 miles distant. In his opinion, with the end of *Rolling Thunder* in 1968, the Americans seemed to ignore the collapse in North Vietnam's war effort that Colvin had seen taking place in Hanoi.

Iron Hand A-4E BuNo 152043 from VA-155 taxies towards the catapults in the bow of *Coral Sea* in 1967. It is armed with AGM-45A Shrikes on the outboard pylons and AGM-12A/B Bullpups inboard. Early AGM-45A-1s were easily confused by having more than one E/F-Band radar emitting within the same area, causing them to miss both. SA-2s were significantly faster than Shrikes, so the latter had to be fired well before a SAM was launched at the Shrike-carrier. BuNo 152043 was lost on May 6, 1969 when it skidded off the flightdeck of *Bon Homme Richard* into the sea after trapping back aboard following a combat mission. (US Navy)

Although crews manning AAA batteries were well prepared for American air attacks prior to the commencement of *Rolling Thunder*, by 1966 revised US tactics following heavy losses also brought revisions to North Vietnam's air defenses. When airfield attacks were finally permitted, the MiGs' tasks became harder, although they never disrupted US Navy Alpha strikes to the same extent they did USAF F-105 bombing formations, which usually approached from the southwest, allowing more time to set up interceptions. MiGCAP tactics used by US Navy F-8 and F-4 squadrons were particularly effective, but engagement opportunities for the crews of these aircraft were reduced by their limited "time over target." As Vice Admiral Dunn explained, "A 20-plane force from an experienced air wing could be on- and off-target in less than one minute" after its short journey across the coast.

As previously noted, more than one pass at a target was seen to be risky, as gunners were more easily able to adjust their aim, or just get lucky. Flying from CVA-64, VA-155's Lt N. E. Holben was brought down at night when he made a third pass at suspected patrol boats east of Dao Cat Ba island in A-4E BuNo 151026 on July 4, 1966. Although multiple attack passes remained a source of losses throughout the war, pilots were still required to make sure that targets were destroyed. Maj A. D. Miller of VMA-211 was forced to eject after his A-4E (BuNo 151045) was hit in the tail by AAA during his third pass at a target near Thon Cam Son on March 20, 1969.

The causes of losses during night attacks were the hardest to establish. Blinded by the glare of their own rocket launches or by target-illuminating flares, pilots could become disoriented. In mountainous terrain, vertigo could easily cause a 500mph jet to fly into the ground. AAA may also have played a part in the downing of an aircraft, although at night that was hard to determine. Despite it being considered safer to attack at altitudes down to just 100ft at night (such heights would not have been contemplated during daytime), with flares illuminating the targets from above the attackers, the risk of being targeted by ground fire was ever-present. The loss of Lt Cdr George Wilkins and VA-153 A-4C BuNo 147732 on the night of July 10, 1966 may have been caused by a combination of all of these factors. The only clear evidence was a streak of fire on the ground seen by another A-4 pilot north of Vinh, and a set of remains returned by the North Vietnamese authorities 33 years later.

Jim Laurier

Lt Cdr William Coakley's VA-153 A-4C (BuNo 147763) was lost in similar circumstances over the North Vietnamese coast near Hoang Xa on the night of September 12, 1966 and he died in the resulting fiery crash. Exactly four weeks later, during a night attack on a convoy staging area near Kien An, VA-23's Lt(jg) Michael Confer dove his A-4E (BuNo 151150) at a 45-degree angle below flares and launched 2.75in. rockets at 2,500ft. Seconds later the jet hit the water just off the coast and exploded in a fatal fireball.

Usually in attacks like this pilots would destroy fewer than ten trucks on a night mission with bombs, rockets and gunfire, but occasionally they would get lucky and leave a burning convoy several miles long. Night strafing with the A-4's 20mm cannon was considered particularly dangerous and unproductive.

Lt Frank Elkins' VA-164 A-4E (BuNo 152075) probably hit the ground while trying to evade an SA-2 on a nocturnal low-altitude road reconnaissance on October 12, 1966. Misjudgment of pull-out altitude probably accounted for the loss of Lt(jg) Jerry Hogan and VA-112 A-4C BuNo 145144 during a January 20, 1967 night attack on several barges on the Song Yen River near Hoang Xa, with flares being used to provide illumination. The ground could be the ultimate risk in daylight too if pilots experienced target fixation in their desire to put their bombs on the correct aim point. Lt(jg) Harry Edwards of VA-153 may have left his pull-out (in A-4C BuNo 148592) from a simultaneous 45-degree dive attack with his wingman on the Trinh Xuyen railway bridge near Nam Dinh a few seconds too late, as his jet hit the ground near the target despite no AAA being reported in the area on October 20, 1966.

In Vice Admiral Dunn's opinion, the A-4 was "the aircraft best suited to the recce role, combining jet speed with precise conventional ordnance delivery and outstandingly good combat reliability and survivability." On a day reconnaissance mission, Skyhawk pilots would seek out vehicular, train or barge traffic to attack with bombs, rockets and 20mm fire. About 20 percent of these missions were flown at night in 1967–68, when Mk 5 or Mk 24 parachute flares would be part of the ordnance loadout.

Sometimes small arms fire claimed a victim but left no evidence to help other flight members establish the cause. Cdr Hubert Loheed, CO of VA-146, disappeared on the squadron's first day on the line on *Yankee Station* flying from USS *Ranger* (CVA-61) on February 1, 1966. At the controls of A-4C BuNo 149527, he released bombs in a dive against barges with the rest of his section off the coast near Vinh before disappearing into the low cloud-base, never to be seen again – Loheed's remains were handed over to US authorities in August 1994. As Cdr F. Hugh Magee subsequently wrote, his fellow VA-146 pilots were at that point "highly trained, well-motivated but very naïve regarding North Vietnamese air defense capability."

Several weeks later VA-146 participated in CVW-14's first 30-aircraft Alpha strike of the cruise, hitting partially constructed Bai Thuong airfield. They were joined by A-4Es from sister-squadron VA-55 and F-4Bs from VF-142 and VF-143. According to Cdr Magee:

> Planning and briefings were elaborate. We were really going to surprise them with an initial feint, a deceptive circuitous route and maximum time at low-level to avoid radar detection. The weather for the strike was great.

OPPOSITE

The crew of an 85mm 52-K gun are firing at A-4s. To the far right of the gun is a PUAZO-6/12 visual aiming device, with a SON-9 radar van sited closer to the weapon. The 52-K's ZIS-151 tractor/lorry is parked to the rear. Spacing of the various items seen here was prescribed by the Soviets. The gun was supposed to be within 100m of the PUAZO and at least 50m from the SON-9 and the power-supply tow lorry. The operational rules for the 52-K stated that the gun and radar had to be sited on flat ground without any tall buildings, trees or obstructions close to it, and preferably with a hill nearby that could be used to calibrate the radar.

A-4C BuNo 148512 plummets earthward on April 20, 1966 after AAA started a fire in its starboard wing during a road bridge attack northwest of Vinh. Cdr John Abbott, the recently appointed CO of VA-113, ejected successfully but later died in captivity. Squadronmate Lt(jg) H. G. Welch joined a rescue cover attempt, and his A-4C (Buno 149495) was hit by 37mm fire. He returned to USS *Kitty Hawk* (CVA-63) but was unable to lower his landing gear and had to eject near the carrier. (Dr. István Toperczer Collection)

We launched, rendezvoused and headed southwest, descending and tanking from our trusty Whales [A-3B tankers of VAH-2 Det F]. The A-4 "Charlie" [A-4C] was a real dog at this point, with full fuel and a full load of 500 pounders. We descended to 500ft and coasted in south of the DMZ [demilitarized zone], confident that as we disappeared off the enemy radar they would dismiss us as another mass gaggle heading for CAS south of the DMZ. About 40 miles inland the strike group wheeled north, hugging the deck up through Laos and circumnavigating the "hot" Plain of Jars. A piece of cake, no flak, no missile warnings, no nothing! I remember thinking to myself that this was "just like a low-level [training mission] out of NAS Leemore with a drop at Fallon. Nothing to this attack business if you use your head."

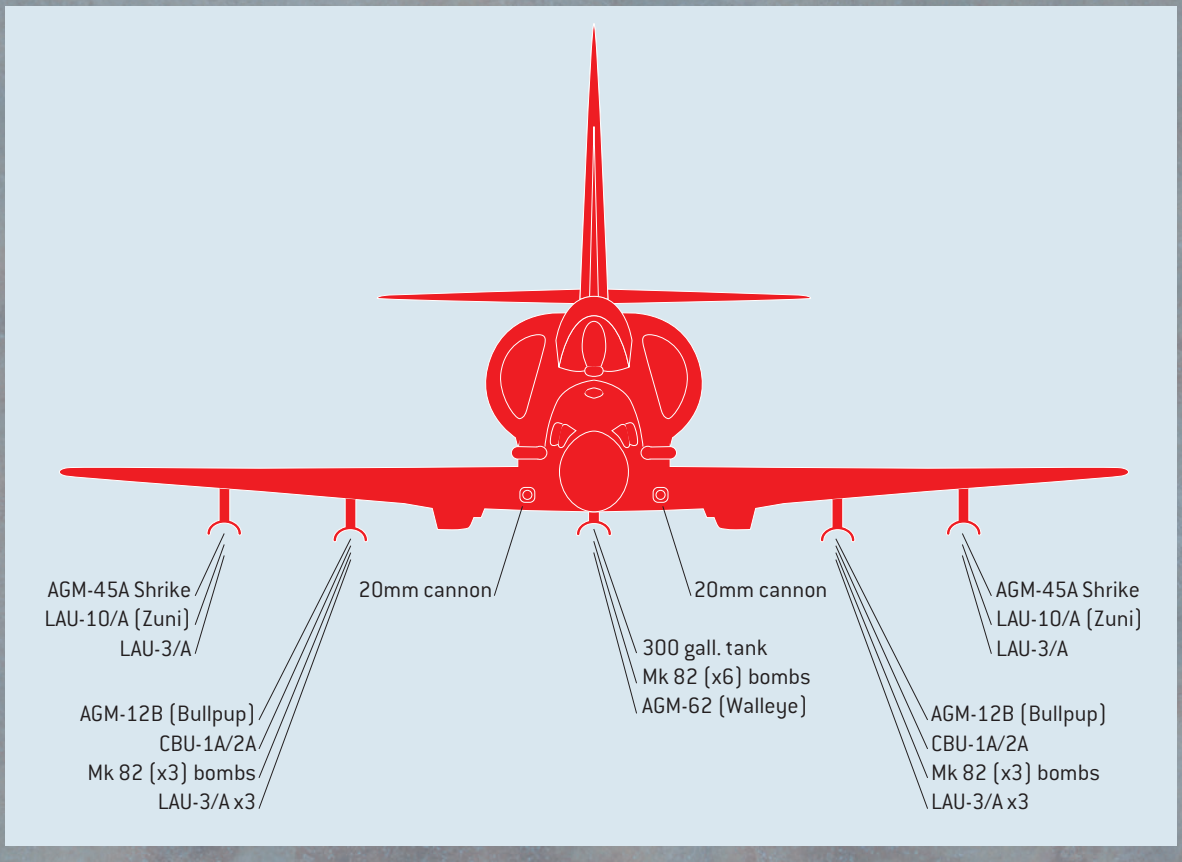
Bai Thuong was masked by the Annam mountains to the west, and well north of the Mu Gia Pass we turned east and clawed our way upward to the top of the ridges, remaining as low as possible. The first indication that something was amiss was the bright, twinkling flashes all around the airfield just prior to the pull-up. The climb to our roll-in altitude was a real struggle for our "Charlies," made worse by the white, gray and black flak puffs which now blanketed the area. We were lucky on that first Alpha. The bombs hit all over the non-operational MiG base. The earth runways were cratered, construction equipment was rearranged and none of the strike group was hit.

During the short, scattered escape to "feet wet" I wondered again did they really know we were coming, and how did they react so fast? Later, I realized that the enemy had an excellent air defense system, and there followed an admiration for a smart and well-trained and equipped foe. Our opponents had probably been laughing and rolling around on their dirt floors as they tracked us throughout our supposed deception.

USAF EB-66B/C ECM aircraft were assigned to most strike packages from March 1967, and they initially had much greater success against "Fire Can" AAA radars than they did with the "Fan Song" units used for SA-2 missile guidance. Their crews frequently reported breaking the radar lock-ons of "Fire Cans," forcing the gun crews to revert to manual aiming. At that stage relatively few weapons were linked to "Fire Can" control in any case, although they remained a major threat as they relied on barrage firing from concentrated locations around tempting targets. EB-66 crews soon identified more than 20 different types of Soviet radar in use in North Vietnam, and the most difficult for them to defeat were the early-warning units that usually had anti-jamming features and diverse frequencies.

The first Skyhawk to be downed by an SA-2 was VA-23 A-4E BuNo 151185 on August 11, 1965, shortly after the missile had claimed its first success in-theater – the destruction of a USAF F-4C Phantom II on July 24. Lt(jg) Donald Brown and Lt Cdr R. D. Roberge were flying a nighttime road reconnaissance mission at 15,000ft near Thanh Hoa when they saw what appeared to be two flares glowing beneath the cloud-base illuminating a bombing attack. Seconds later Brown's Skyhawk was hit and it exploded, killing the pilot. The second SAM detonated below Roberge's aircraft, igniting some of his ordnance (which he jettisoned). Despite the damage, he managed to return to USS *Midway* (CVA-41), where deck crew counted 50 large shrapnel holes in his A-4E and numerous smaller gashes.

A-4 SKYHAWK FLAK SUPPRESSION/*IRON HAND* WEAPONS LOAD-OUT



The US Navy's response to Brown's downing was a 76-sortie SAM search effort, codenamed Operation *Iron Hand*, between Thanh Hoa and Haiphong on August 12–13. None of the aircraft involved had any specialized equipment or armament to tackle the missiles at that stage, however. Although no sites were found, the attempt cost the lives of two pilots as five US Navy aircraft fell to ground fire. Seven others sustained considerable damage.

Three losses were Skyhawks, and the first was VA-155 A-4E BuNo 150067 on August 12 – 37mm shells blew off its starboard wing flap, wingtip and the majority of the right aileron, together with most of the starboard tailplane and elevator. Lt W. T. Fidelibus managed to get his tough little jet under control, despite this major damage, and flew it for 250 miles back to *Coral Sea*, including an in-flight refueling en route. He lowered the undercarriage for a carrier approach but soon realized that there was insufficient elevator control for a safe landing and he had to eject near the ship.

VA-153 A-4C BuNo 148475, also embarked in *Coral Sea*, was hit by AAA at very low level as its pilot, unit CO Cdr Harry Eugene Thomas, searched for the SAM site that had killed Lt(jg) Brown. His squadronmates saw the aircraft roll inverted and hit

A-4 pilots were most likely to be opposed by weapons like this heavily camouflaged, optically guided M1939 (61-K) 37mm gun. Loaders stand ready with ammunition clips as the firing signal is given. At night, streams of fire from such weapons were dubbed "bright red basketballs" by Skyhawk pilots. (Dr. István Toperczer Collection)

the ground before Thomas could eject. The third Skyhawk downed, A-4C BuNo 148564 of VA-22 embarked in *Midway*, had its nose-cone blown off by a heavy-caliber shell and debris entered the air intake. Despite severe loss of power, the jet survived a five-mile flight out over the coast, allowing Lt W. E. Newman to eject safely near a search and rescue destroyer.

The SAM search had been arranged in predictable rectangular patterns at 1,000ft, although poor visibility forced many of the A-4 pilots to operate below 500ft, putting them at severe risk from prodigious ground fire.

BLACK BOXES

For much of *Rolling Thunder* the US Navy's ECM opposition to individual SON-9 "Fire Can" and early-warning radars was available only in the form of a few aged EA-1F Skyraiders that orbited offshore at 140 knots and flew towards the radars to jam them. By September 1965 some A-4Es were fitted with Project *Shoehorn* Sanders AN/ALQ-51A "gate stealer" radar deception equipment that "shifted" the aircraft's apparent position on a hostile radar screen by up to 1,000ft. On September 20 *Iron Hand* pilots used their Sanders AN/ALQ-51As to divert six SA-2s that had been fired at them. AN/ALQ-51A could tackle only one emitter at a time, and Soviet radar operators learned to beat it – unlike the comprehensive barrage jamming from EB-66s – by differentiating false returns from genuine ones.

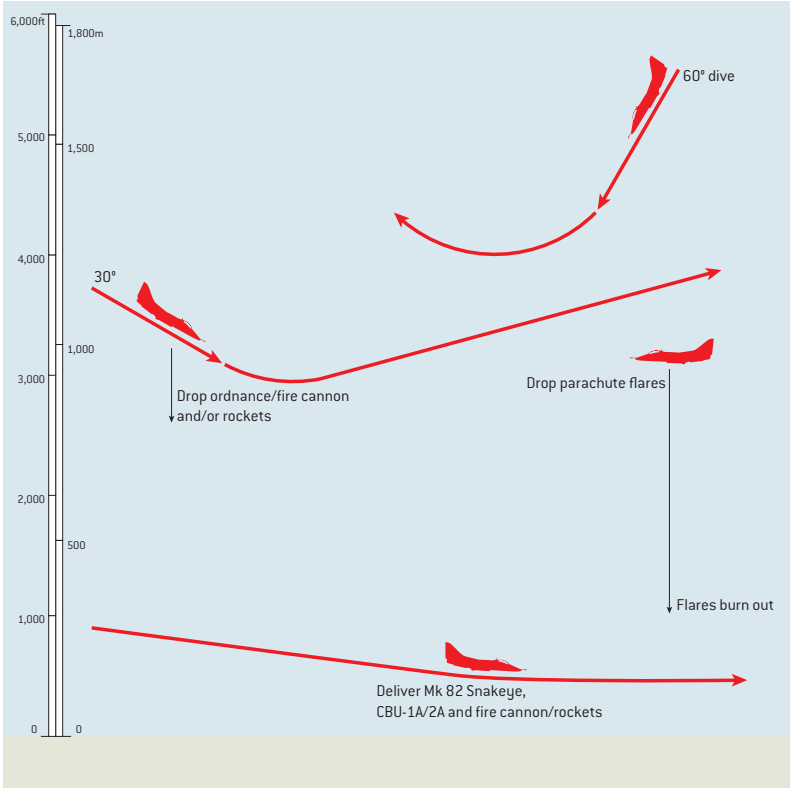
The system was packed in two large boxes in the space beneath the Skyhawk's cockpit that had previously been occupied by the 20mm ammunition cans and one gun. A replacement ammunition magazine was installed above the gun bay, but it could hold only 40 rounds for the remaining Colt Mk 12 cannon. A-4s also received AN/ALE-18 chaff and flare dispensers, installed under the rear fuselage.

On October 17, 1965, the first successful *Iron Hand* attack by A-4Es took place when four aircraft from VA-72 and VA-86 (part of CVW-7 and embarked in USS *Independence* (CVA-62)) hit a SAM site near Kep with napalm, destroying most of its contents. By mid-1967, hitting SAM sites took priority over other targets, and pilots would attack any that they saw, regardless of their primary targets. Although SA-2s could be a formidable threat, particularly when fired in salvoes of three, their main effect was to force aircraft to fly lower, exposing them to AAA. Making evasive maneuvers against multiple SAMs also sapped the energy of a bomb-laden A-4, and pilots attempting to regain altitude found that their forward speed was reduced below 300mph. Without the boost of an afterburner, regaining that energy in a Skyhawk was a slow process that also made the gunners' task easier.

Iron Hand Skyhawk attacks on SAM batteries and their radar guidance vans could be successful, but there were always difficulties in knowing whether such sites were occupied. Long delays in permitting air attacks on the first sites in 1965 allowed the

North Vietnamese four months to establish many alternative sites, as well as train SA-2 operators and missile assemblers. The Johnson administration initially refused permission for SAM sites to be targeted, partly because Russian technicians were known to be operating them.

Clever camouflage often prevented speeding pilots from seeing stored missiles or local AAA sites. James Cameron, a British journalist who was permitted to travel through North Vietnam at this time, noticed how, as darkness fell each night, convoys would start up and emerge from forest cover. Many of the heavy Soviet lorries on the move would be towing AAA weapons that had been buried under layers of branches and leaves. He also spotted that in the corners of most paddy fields were stacks of rifles ready for use by the rice farmers.



Although these varied according to operational conditions, the 30-degree dive was standard in the mid-1960s. A 60-degree dive was trialed at Naval Ordnance Test Station China Lake, California, and used in action. It gave better accuracy, but proved to be hazardous at night. The AGM-62 Walleye missile was launched at a slant range of between two and eleven miles from the target. Shrikes were often launched in a "loft" delivery from a 45-degree climb, with the missile reaching 20,000ft before it descended on a radar target. TPQ-10 radar blind bombing was performed in straight and level flight from 12,000 to 16,000ft.

On November 6, 1965 three *Iron Hand* A-4Es identified and attacked a site near the Hai Duong bridge, destroying an SA-2 on its launcher. A 37mm gun emplacement that had damaged one of the Skyhawks was also destroyed, and three SA-2s which were fired at them were evaded. The following day two *Iron Hand* A-4Es were part of a five-jet formation that bombed SAM sites around the Me Xa highway bridge near Nam Dinh. At least two "Fan Song" vans and two SA-2s from the 236th Missile Regiment were destroyed, although post-strike reconnaissance showed that a further 18 SA-2s on their "transloader" semi-trailers or SM-63-1 turntable-launchers had survived.

Although the A-4E (BuNo 150071) of strike leader Lt Cdr Charlie Wack from VA-163 was hit by AAA as he rolled in on the target, he continued with his bomb run. The jet's engine developed severe vibration as he turned towards the coast and his wingman saw flames burning through the rear fuselage. The Skyhawk kept going until its control lines were burned out 15 miles offshore, at which point Wack ejected and was quickly retrieved by a USAF HU-16 amphibian flown by 1Lt Joe Kirby. His subsequent short stay at Da Nang and some USAF hospitality restored his spirits but left him with a memorable hangover.

VA-23, the first fleet unit equipped with the A-4E, also introduced the AGM-45 Shrike to combat use. The first ten shots with the missile were against "Fire Can" AAA radar (rather than "Fan Song" SAM guidance equipment), with five claimed hits. *Iron Hand* sections became an essential part of the twice-daily Alpha strike packages throughout

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While North Vietnamese forces engaged the US Army in the disastrous battle of Ia Drang, naval strikes were attempting to destroy the Hai Duong bridge, a major army supply route between Haiphong and Hanoi. The NVA concentrated heavy AAA defenses around this vital target. On November 17, 1965, a 40-strong Alpha strike force from *Oriskany* and *Bon Homme Richard* set out to bomb the bridge, meeting massive AAA fire as soon as it crossed the coast. An F-8E Crusader was downed and Lt Cdr Roy Bowling's VA-163 A-4E (BuNo 151083) was hit as he dropped his Snakeye 500lb bombs on the target. He pulled out at 100–150ft and attempted to escape, but his right tailplane had been blown off by a 57mm shell. The aircraft rolled to the right at very low altitude and Bowling ejected moments before it hit the ground. In an attempted rescue two more aircraft were shot down, and Bowling's fate was unknown until his remains were returned in 1977.

Operation *Rolling Thunder*. One or two flights of A-4s with Shrikes, Zuni rockets or Mk 82 bombs led each strike, often launching some pre-emptive Shrikes ahead of the bombers to make enemy radar operators switch off their equipment temporarily. Sometimes, a Zuni was fired to trick radar operators into thinking that a Shrike had been launched at them.

The NVA became adept at locating its defenses in "no go" civilian areas to try and avoid attack, although this ruse failed on July 19, 1967, as Vice Admiral Dunn explains:

> The photo interpreters had turned up a photo of a SAM site in the middle of a football stadium in a city ten miles south of Hanoi. We were ordered to hit that target with the first Alpha strike the next day. The day dawned bright and clear. Briefings, launch from *Constellation* and rendezvous led by my squadron [VA-146, flying A-4Cs, with a VA-55 *Iron Hand* A-4E flight] went smoothly, all attack crews salivating at the chance to hit such a well-marked target and take out those missiles that had wreaked such havoc among us.
>
> The flak grew more intense as we weaved and jinked our way in. Cockpit warning systems screeched with AAA alarms and missile alerts. SAMs began to rise to meet us and we jinked some more. Shortly, in the distance, peering through the black puffs of the 100mm, the white puffs of the 57mm and tracers from the 37mm, we sighted the target. Closing in and still weaving, there they were! Missile launchers sitting as pretty as you please right in the middle of the stadium. We rolled in on the target in closely-spaced 50- to 60-degree dives, ignoring flak and SAM calls but still jinking in the dive and steadying at about 6,000ft to pickle at 5,000ft. In short order each of our 12 aircraft released four 500lb bombs apiece, two from each underwing TER [triple ejector rack].
>
> A quick look back seemed to show all ordnance on target within the confines of the stadium, and with fire and black smoke rising. A reconnaissance aircraft following close behind our drop brought back pictures confirming what we thought we saw. Several days later we got word of a headline and lead story, complete with pictures, in a Hanoi newspaper – "Yankee air pirates destroy school children's football stadium!" The pictures showed wrecked seats and torn up turf, but no sign of the missiles or their launchers.

Skyhawk pilots on armed reconnaissance flights were particularly at risk from AAA because they had to fly as low as possible to see their targets. Such missions usually involved divisions of four aircraft, although they were also undertaken by two-jet sections. With the latter, the lead pilot would seek targets of opportunity such as gun sites for his wingman, who remained on patrol at a higher altitude. Smoke haze from burning crop fields, low cloud and dense jungle cover all contributed to the difficulty in seeing targets, and threats – particularly the heavily camouflaged anti-aircraft weapons that awaited them virtually anywhere in North Vietnam.

The numerous, easily transportable, 37mm weapons were particularly menacing, as they were deadly at 10,000ft – well above the appropriate altitudes for accurate bombing. Their appearance, along with other anti-aircraft defenses, throughout Laos and southern North Vietnam forced fighter-bombers to include flak suppression ordnance in their bombloads. Strikes within the vicinity of Hanoi, Haiphong, Vinh or Thanh Hoa were certain to attract the heaviest flak, but guns were a hazard almost anywhere. For US Navy aircraft, from 1968 a flak suppression load-out often included Mk 20 Rockeye CBUs.

Even when USAF F-4s were able to direct laser-guided bombs against AAA sites in night attacks during Operation *Commando Hunt VII* in Laos in 1971–72, they could

claim only 30 of the 252 AAA sites destroyed during that operation. Just ten percent of their bombs landed close enough to cause damage to the weapon or its crew, with many missing the target by more than 1,000ft. This was primarily because the attacking aircraft had to jink constantly to avoid ground fire from targets whose location was imprecisely known. Even the 15,000lb BLU-82 bombs dropped by C-130s on clusters of gun sites in southern Laos failed to silence the majority of the weapons because inaccurate maps made precise targeting by *Combat Skyspot* radar impossible.

Smaller, hand-held height- and range-finding devices were just as available to AAA batteries in the field as the heavy PUAZO-3/5 units. Steel helmets were scarce in the mid-1960s, with those used being mainly captured items from the French. Supplies from the Soviet Union were eventually distributed to some AAA gunners to replace their "sun helmets." (Dr. István Toperczer Collection)

An outstanding example of *Iron Hand* skill was displayed on April 20, 1967 by VA-192's Operations Officer, Lt Cdr Mike Estocin, flying from *Ticonderoga* as part of CVW-19. Determined to destroy as many SAM batteries as possible, he led a three-aircraft *Iron Hand* flight against three 285th Missile Regiment SA-2 sites near Haiphong. His approach was to fly as close as possible to a site before releasing his missiles. All three sites were destroyed, but Estocin's A-4E received substantial AAA damage to its wings.

With one Shrike still left, he returned to the target to expend it, despite rapidly increasing fuel loss. Estocin then went "feet wet" and linked up with an A-3 "Whale" tanker that towed him back to *Ticonderoga*, pumping in fuel a little faster than his aircraft was leaking it out. Two miles from CVA-14, he detached from the tanker and headed for the deck, knowing that he had fuel for only one attempted landing. Although Estocin's A-4E caught fire on its final approach, he made a safe landing into the barrier and the fire crew doused the flames as he descended intact from the cockpit.

Lt Cdr Estocin was SAM hunting again on April 26, 1967 – the day that his squadronmate Lt(jg) J. W. Cain was shot down by AAA in A-4E BuNo 152076 during VA-192's Alpha strike attack on a fuel dump in Haiphong. Shortly after Estocin's *Iron Hand* section had lofted a Shrike ahead of the strike force, he saw an SA-2 rising towards him as he was climbing back up to 12,000ft. Having probably positioned himself to attack its launch site, he began an evasive diving turn just as the missile exploded close to his aircraft. With his A-4 (BuNo 151073) on fire, he rolled and dived towards the ground, before pulling out at 2,000ft. Estocin's aircraft was by now burning furiously as the pilot headed for the coast, the Skyhawk gradually losing speed and being almost hit by another SAM that passed close by. Future MiG killer Lt Cdr John Nichols of VF-191 accompanied the crippled A-4E in his F-8E, noticing severe damage to its forward fuselage and seeing Estocin apparently slumped forward in his cockpit, unresponsive to radio messages. Just short of the coast, the aircraft rolled inverted at 1,000ft, its stores were jettisoned as their wiring burned out and it crashed. Estocin was posthumously awarded the Medal of Honor shortly thereafter, thus becoming the only US Navy jet pilot to ever receive that award for a combat mission.

North Vietnamese records cite April 25, 1967 as the day attacks on Hanoi began, and three A-4s were lost, but all over Haiphong. Lt Charlie Stackhouse of VA-76 was

Fully loaded with Mk 82 Snakeyes, two A-4Es from VA-163 head target-bound in the early summer of 1966. The lead aircraft, BuNo 152100, is being flown by unit CO, and Korean War veteran, Cdr Wynn Foster. He was hit by shrapnel from an exploding 57mm shell while flying this jet on July 23, 1966 during an attack on a POL facility north of Vinh, Foster having his right forearm severed from the elbow. Despite this, he managed to nurse his crippled jet back over the sea, where he successfully ejected and was quickly recovered. (US Navy)

intercepted by four MiG-17s from the 923rd Fighter Regiment, the aircraft being led by VPAF ace Nguyen Van Bay. As he turned away after bombing an ammunition dump, Stackhouse was focusing his gunsight on one of the MiGs when his A-4C (BuNo 147749) was hit by 37mm shells from Ha Dinh Bon's MiG-17, knocking out its engine. Stackhouse had to eject from his jet, spending six years as a PoW.

At much the same time as Stackhouse was being pursued by MiGs, an *Iron Hand* flight was tackling a SAM site north of Haiphong. Lt Cdr F. J. Almberg of VA-192 had just fired his third Shrike missile when a near miss from an SA-2 severely buffeted his aircraft. With no damage apparently having been done to his A-4E (BuNo 151116), he pressed on with the mission until a fourth SAM exploded close to the aircraft and badly damaged its hydraulics. Almberg managed to go "feet wet" and eventually ejected about 40 miles southeast of Haiphong as he neared a search and rescue destroyer. He was quickly picked up by a US Navy helicopter.

Later that same day a second SA-2 hit resulted in a remarkable recovery for VA-212's Lt(jg) Al Crebo and a graphic demonstration of the Skyhawk's survivability. Crebo had just popped up to 8,000ft to begin his dive on an ammunition dump on the southern outskirts of Haiphong when a SAM exploded close to him while he was flying at just 220 knots – at that speed his AN/ALQ-51 system was unable to deflect a fast-approaching SAM. The explosion flipped the A-4E (BuNo 151102) over onto its back. Shortly after Crebo had righted the jet and dropped his bombs, he found that the aircraft was uncontrollable and losing its electrical systems. He duly disconnected the hydraulic system and flew it manually back in the direction of *Bon Homme Richard* – Lt Cdr F. J. Almberg had done a similar thing that same morning in his SAM-crippled Skyhawk.

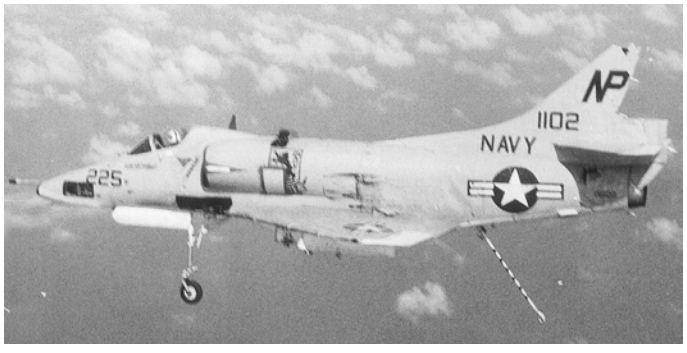
Photographs taken of Crebo's crippled Skyhawk by section leader Lt Tom Taylor showed that the entire rudder and the top of the tail fin had been torn away, several access panels were missing, there were large holes through the rear fuselage and fuel was streaming from a punctured tank in his left wing. On approach to the carrier, Crebo found that only the nose landing gear and tailhook would extend, with the main gear jammed shut by buckled underwing panels. As he climbed away his engine flamed out, starved of fuel. Crebo ejected and was picked up by destroyer. Although the Haiphong missile batteries had fired at least 30 SA-2s that day, only two found their mark.

As the Hanoi AAA regiments gained experience, their claims for American aircraft shot down increased markedly, although US figures indicate considerable double-counting. However, there were often severe losses. On October 17, 1967, a 37mm battalion protecting Dap Cau railroad yards claimed five US strike aircraft. Three F-105Ds from the same 388th TFW flight of four were lost within one minute as they began their bombing runs at 19,000ft. On other days the claims were clearly unrealistic. For example, the NVA "score" for November 19, 1967 was allegedly 19 aircraft

destroyed, but "only" eight were recorded in US sources on one of the worst days of the conflict for losses to SAMs, AAA and MiGs.

SEMPER FI SKYHAWKS

There were even risks associated with radar bombing missions (known as "TPQs," with pilots guided by a ground radar station), as SAMs and radar-directed AAA could penetrate the thick cloud that made a TPQ-10 attack necessary and hit the bomber formation without warning. VMA-223 A-4E BuNo 151123 and its pilot, Capt Claude Williams, were lost in that way on the night of November 24, 1966 northwest of Chu Lai. VMA-224 A-4E BuNo 150020 had also vanished from its formation in the same general area on September 8, 1966, killing 1Lt John Fischer.



Lt(jg) Al Crebo of VA-212 heads for *Bon Homme Richard* in his mortally wounded A-4E BuNo 151102 on April 25, 1967. Part of the large Alpha strike targeting an ammunition dump in Haiphong, Crebo's jet had been damaged by a SAM, losing most of its vertical tail and various fuselage panels and systems. Crebo could only lower his nose-gear and tail-hook, making a safe recovery aboard ship impossible. He ejected close to the carrier and was retrieved by helicopter. (US Navy)

Although the vast majority of the A-4s lost in combat by the US Marine Corps fell to AAA because they were primarily flown over South Vietnam or just north of the DMZ, the rapid proliferation of SA-2s throughout North Vietnam meant that pilots had to be fully cognizant of the potential SAM threat anywhere in-theater. Proof of this came during a night TPQ-10 mission just 15 miles north of the DMZ on May 10, 1967 when A-4E BuNo 151997, flown by Marine Air Group (MAG) 10 staff officer Maj Robert Snyder, was badly damaged by an SA-2 that detonated nearby. Having briefly managed to coax the Skyhawk (from VMA-223) south, he was killed when it crashed in the DMZ.

Following the construction of a number of SAM sites immediately north of the DMZ, the US Marine Corps commenced its own *Iron Hand* operations on the night of July 6, 1967. During the course of the mission A-4E BuNo 151032 of VMA-311, flown by Maj Ralph Brubaker, was shot down. Lt Col Bill Egen recalled that Brubaker "was on a SAM suppression mission with Mk 82s and was hit by an SA-2 [two were launched], but he ejected and spent the night in a bomb crater in the DMZ, before being rescued by [a USAF HH-3E] helicopter [that was hit four times by enemy fire when it landed to pick Brubaker up]." However, as Bill Egen explained, "some comments [in official records] mention *Iron Hand* as a mission, but that was not a designated role for us in the sense that someone else was attacking while we tried to suppress the SAMs. VMA-311 flew SAM suppression missions after Snyder was killed, but there is no mention of Shrikes being fired."

As previously noted, the US Marine Corps' main A-4 mission was CAS for its own troops, and that meant extensive flak suppression ahead of an insertion of Marines by helicopter. Lt Col Egen, flying from Chu Lai air base, recalled:

> CAS varied from troops in contact to critical targets that the "grunts" wanted to be taken out. It sometimes included threat suppression based on awareness, probably with an airborne FAC [forward air controller] putting ordnance on various targets to enable an additional flight to strike a known target.
>
> The major Alpha strike that I flew on was a "Super Gaggle" at Khe Sanh [a formation of up to 16 escorted US Marine Corps CH-46 helicopters supplying troops manning positions

VMA-211 flew A-4s for 33 years from September 1957. It operated from Chu Lai from October 1965 until 1970, returning to the war in May 1972 from Bien Hoa AB with MAG-12 in response to the North Vietnamese invasion of the South Vietnam. A-4E BuNo 151088 is positioned on the SATS launcher with Snakeyes in the summer of 1967, its faded markings being the sign of a hard life pushing back a determined enemy. This Skyhawk was shot down by ground fire on August 11, 1967 during a CAS mission near Hiep Duc, its pilot, 1Lt K. A. Berube, being killed. (US Marine Corps)

on hills around the base] and arose out of losses to some of the helicopters in late February 1968. We would launch 12 A-4s from various squadrons and lay down smoke for the CH-46s going in to drop off and pick up Marines. We provided simultaneous suppressive fire, with rockets and bombs applied to the ridges and valleys around the hill tops. It was a very coordinated effort, with the helo pilots on the phone concurring with the plans. A TA-4F Skyhawk FastFAC had overall responsibility for the effort, and with up to four of these missions per day for several weeks, the heavy helo losses stopped.

The supply effort took up to 40 minutes to complete, during which time A-4s and US Marine Corps F-4 Phantom IIs and A-6 Intruders blasted the terrain around the hills and the CH-46s would be vulnerable to any AAA, including AK-47s below 1,500ft. The success of the "Super Gaggle" (and its AAA suppression) was seen as the turning point in the crucial re-supply effort for Khe Sanh.

The last US Navy Skyhawk loss over South Vietnam was BuNo 150000 of VA-212 on June 27, 1966 after an unexplained engine fire. TF 77's attention then turned exclusively to North Vietnam, as USAF and US Marine Corps strength in-theater had become sufficient to tackle the in-country war. The final Skyhawk loss of the entire conflict occurred on September 26, 1972 during the defense of An Loc, besieged by the NVA. Both VMA-211 and VMA-311 from MAG-12 had been sent to Bien Hoa air base (a new location for US Marine Corps aircraft) on May 17, 1972 in response to concerns about NVA divisions that had been detected in Cambodia.

Led by Lt Col Willis E. Wilson, VMA-211 flew in excess of 36 CAS sorties a day against the six NVA and Viet Cong regiments that were surrounding An Loc and the city's Quan Loi airfield. By that time the enemy's already deadly air defenses had been enhanced by the addition of SA-7 shoulder-launched anti-aircraft missiles. However, the loss of A-4E BuNo 151099, flown by Capt James P. Walsh, on September 26 was all too typical of hundreds of others during the conflict. Under FAC direction, Walsh made a 30-degree dive on NVA troops and their armored vehicles and his aircraft was hit by 37mm gunfire shortly after he had dropped his ordnance on target. With his jet on fire and the controls no longer responsive, Walsh ejected. An attempted rescue by helicopter was beaten off by ground fire and he became the last US Marine Corps PoW.

The US Navy had suffered its final Skyhawk combat loss 20 days earlier when A-4F BuNo 155021 of VA-212 was hit in the tail by 23mm AAA while attacking trucks on a coastal road south of Thanh Hoa. As the aircraft's engine wound down, Lt W. F. Pear headed out to sea and ejected when his controls froze. He was soon rescued by a US Navy helicopter. VA-212 and sister-unit VA-55 had lost a total of seven Skyhawks (six in combat) between them during *Hancock*'s marathon 165 days on the line, with two pilots listed as Missing in Action, two captured and three recovered. VA-164, CVW-21's third A-4F unit embarked in CVA-19, had survived the cruise without suffering any attrition.

STATISTICS AND ANALYSIS

Of the 271 US Navy A-4 losses (combat and operational), 177 occurred over North Vietnam. Skyhawk casualties were roughly twice those of other US Navy fixed-wing attack aircraft, and this was primarily because A-4 units made 107 cruises between 1964 and 1973 compared with 56 for A-7 Corsair II squadrons and 33 for units equipped with the A-6 Intruder. A-4s were the main carrier-borne strike aircraft throughout *Rolling Thunder*. By far the worst year was 1967, when 77 were destroyed as *Rolling Thunder* attacks on central Hanoi and Haiphong intensified.

US Marine Corps Skyhawk combat losses totaled 91, including ten TA-4Fs whose missions were mostly flown over South Vietnam. Only one US Navy A-4 fell to a MiG pilot and 32 were attributed to SAMs. Of the Skyhawks lost, around 140 were casualties of AAA batteries or small arms, with another 36 destroyed by SAMs.

The first Skyhawk to be shot down was the aircraft flown by Lt(jg) Everett Alvarez, whose jet was the only A-4 combat loss in 1964. There were, however, six operational losses that year owing to engine failures, incorrect catapult settings or on-deck accidents. By 1967, the loss rate from intensive *Rolling Thunder* operations had risen to the point where 99 US Navy and US Marine Corps Skyhawks were destroyed that year, 89 of them in combat and all but 16 almost

One of the ten Skyhawk losses by both services in 1972 was VA-212 A-4F BuNo 154972 on July 9. Cdr Frank Green, leading a nighttime armed reconnaissance mission, dived through light haze to attack a truck with its lights on. His aircraft hit the ground and exploded, killing him. Damaged trucks were sometimes surrounded with guns as flak traps. (Dr. István Toperczer Collection)

Lt(jg) Denny Sapp of VA-55 finishes his preflight check of A-4F BuNo 155013 on the flightdeck of *Hancock* during the early stages of the carrier's marathon 1972 combat deployment. (US Navy)

certainly to AAA. Losses, averaging six per month, were approaching the monthly procurement rate of ten Skyhawks. This grim total was not far short of the 113 F-105 losses suffered by the USAF in 1967, and was higher than the overall US Navy average.

The causes remained unconfirmed in around a quarter of losses over Laos but AAA was the most likely. In July 1967 an unusually high total of 17 A-4 losses included 13 to AAA and two to SAMs. Overall, July was the blackest month, with 28 US Navy and US Marine Corps aircraft written off and a further 21 lost in the fire on board USS *Forrestal* (CVA-59), including six A-4s from CVW-17. The following year, the 58 A-4 losses exceeded those of F-105s by ten. However, in Vice Admiral Bob Dunn's opinion, US Navy losses were "not catastrophic and never compromised performance on the part of the rest of the aircrews."

Concerns about the effectiveness of NVA defenses were a dominant aspect of Secretary of Defense Robert S. McNamara's initial analysis of strikes, from *Flaming Dart* up to March 2, 1965, when *Rolling Thunder* began. By then 11 aircraft, including four from the US Navy, had been lost and 41 damaged by flak. The Secretary of the Air Force, Eugene Zuckert, anticipated a "credibility" problem when the public realized that multimillion-dollar aircraft were being destroyed by "unsophisticated" defenses. Examination of combat reports showed that aircraft were particularly challenged by small arms fire. Automatic weapons seemed to be wielded by every foot-soldier, "so barrage capability of small arms fire is a threat up to 1,000ft in or near target complexes." Most damage had resulted from this type of gunfire, and it would only get worse.

By the end of the first year of the war North Vietnam had mustered around 500,000 military and civilian personnel to man its defenses. In 1965 they succeeded in destroying 91 US Navy aircraft with AAA and small arms fire. Between May and November 1965, 37 A-4s from *Oriskany* alone were damaged by ground fire, in addition to six combat losses and two operational casualties. The following year that grim total of US Navy losses would rise to a wartime peak of 105, and in 1967 there were a further 99 combat and operational write-offs. CVW-16's July 1967 to January 1968 combat deployment brought 20 A-4 combat losses (three in one day) out of a total of 29 aircraft destroyed. It also had three Skyhawks written off in operational accidents, and no fewer than 43 A-4s suffered combat damage, much of it requiring extensive repairs.

By war's end 38 percent of TF 77 losses were A-4s – a figure that reflects the fact that Skyhawk units flew one-third of the US Navy's dangerous missions over North Vietnam. Charts were devised for aircrew showing that the chances of suffering a AAA hit decreased as an A-4's speed increased from 250 knots to 450 knots, although the risks still remained high above that speed. Undoubtedly the concentration of AAA and SAMs in the immediate vicinity of prime targets was responsible for the majority of losses. Capt Len Giuliani, a veteran of 357 A-4 and A-7 missions in Southeast Asia, calculated that up to 90 percent of his squadron's losses (VA-153) occurred within 1.5–2 miles of a target. Losses sometimes came in clusters in otherwise accident-free cruises as Capt Denny Sapp recalled:

I was squadron duty officer the day that Lt Tom Latendresse [flying A-4F BuNo 155048 of VA-55 on May 27, 1972] was bagged by AAA. He had been on an *Iron Hand* to protect the road recce flights in the area. He had picked his own target and was in a 45-degree dive when 37mm AAA hit his wing-root. He ejected at around 3,000ft and 500 knots. He was severely injured and taken prisoner. On that same launch, after Tom had gotten airborne, his room-mate Lt Jack Zerr [in A-4F BuNo 154197 from the flak suppression flight] had an engine failure just ahead of the ship. He ejected, unscathed, and was picked up by a helicopter within minutes. On that same day another VA-55 aircraft was in Da Nang refueling ahead of a return flight to the ship. A mechanical problem made the wing tanks over-pressurize, causing a massive fuel leak and the loss of the aircraft. Three jets lost in one day from our squadron was rare for that time in the war.

Seventh Fleet analysts observed that persistent low cloud ceilings limited attacks to periods of clear visibility, so the North Vietnamese organized their defenses to expect attacks during those times. Typical cloud ceilings of 3,500ft for over half the time also affected bombing tactics, as pilots were unable to make more accurate 45-degree dive attacks. Bombing from above 3,000ft in fair visibility reduced the small arms threat, but at lower altitudes, in a 30-degree dive below clouds, aircraft were vulnerable to all forms of firepower and loss rates approached a crippling 30 per 1,000 sorties. Although the changed tactics satisfied the statisticians in producing pre-*Rolling Thunder* loss rates that were within the range experienced in Korea or World War II (0.3 to 0.9 per 1,000 sorties), the analysts' predictions that those rates would fall below the late 1964 to early 1965 0.6 per 1,000 would be very far from true as *Rolling Thunder* progressed.

Squadron commanders in Southeast Asia also sought to make their missions safer by being given greater flexibility in managing them, rather than relying on the clumsy micro-management imposed by the Johnson administration in which every detail of timing, weaponry, routes and rules of engagement was laboriously communicated and enforced thousands of miles away from the battlefield. The commanders also wanted the freedom to launch reconnaissance sorties in such a way that they would not signal an imminent attack by flying over the target area shortly before a strike package was scheduled. They recommended the use of RB-66 (later re-designated EB-66) ECM aircraft on future strikes to neutralize the "Fire Can" fire control radars that were linked to the heavier AAA batteries. Far more realistic training for attack pilots was also suggested, using real ordnance and simulated, camouflaged targets, rather than traditional, simplistic bombing ranges.

Meanwhile, the rapid build-up of anti-aircraft defenses continued as imports from the Soviet Union and China arrived at Haiphong docks and by rail. While it was difficult for reconnaissance and other intelligence agencies to give exact figures, particularly for the smaller weapons, the statistics compiled by the Pacific Air Force for July–September 1965 were alarming:

	Light Guns	Medium Guns	Automatic Weapons	Total
July 5, 1965	920	1,386	639	2,945
September 30, 1965	1,183	1,747	1,229	4,159

By the end of 1965, with more guns arriving from China, the CIA estimated that North Vietnam's defenses were increasing by 205 extra anti-aircraft weapons per month. The risks of flying within range of NVA anti-aircraft defenses became obvious in 1965 when a report by CVW-15 embarked in *Coral Sea* showed that 20 of the 22 aircraft hit by flak during its first war cruise from December 1964 to November 1965 had been flying at an altitude below 2,000ft at the time they were struck. CVW-7's A-4 squadrons on board *Independence* that arrived in-theater to replace CVW-15 and *Coral Sea* raised the minimum altitude to 3,000ft, but there were many variations in that tactic during the conflict.

On its first combat cruise *Coral Sea* lost 21 aircraft, including 11 from its two Skyhawk squadrons (VA-153 and VA-155), and all were attributed to AAA. The carrier's seven war cruises kept the vessel in action for 875 days of the war, from the initial *Flaming Dart* strikes to the wind-down in 1973. During that time its air wings – CVW-15 was embarked for six cruises and CVW-2 for one – lost 95 aircraft (the equivalent of an entire air wing), 69 of them being combat casualties. On four cruises, CVW-15 included two A-4 squadrons, and their attrition totaled 27 jets, including three operational losses – 17 were attributed to AAA. The raising of the minimum altitude to 3,000ft was a factor in the reduced losses on CVA-43's second (five combat losses) and third (four losses) *Rolling Thunder* cruises, but by 1967 one A-4 pilot from VA-76 described attempts at flak suppression as "like peeing against the tide."

The introduction of SA-2s was what, in the opinion of veteran Skyhawk pilot Lt D. D. Smith, "put the hate in the game" by forcing attack formations down into the flak. Although SA-2s were viewed as formidable threats and SAM suppression was vital for each air strike, the missiles accounted for only 32 of the 362 A-4 losses during the war. However, SA-2 sites were heavily defended by AAA, and any A-4s that were assigned *Iron Hand* attack duties against them would be more likely to be hit by flak. In July 1965 one site was photographed with a battery of eight 100mm KS-9 guns next to it, together with numerous weapons of 37mm, 57mm and 85mm caliber.

By the time US Navy pilots from *Constellation* and *Coral Sea* were finally given permission to attack the MiG base at Phuc Yen on October 24, 1966, its well-prepared AAA defenses were estimated at 72 85mm guns and 120 of 27mm or 57mm caliber, together with 35 operational SAM sites within range of the strike force.

SA-2 batteries relied increasingly on camouflage, as multiple gun sites tended to reveal a SAM site from the air. USAF *Wild Weasel* pilots reported sites that were so heavily disguised that their contents could be seen under the camouflage netting only by flying close to them at very low altitude. The success of *Iron Hand* can be judged by the increase in the number of SAM launches needed to down a single US aircraft from 13 SA-2s in 1965 to 55 in 1967.

Radar-guided guns were considered so dangerous that both the US Navy and USAF sought new technology to reduce the risks. Camera-equipped Firebee drones, air-launched from DC-130A transport aircraft, were used to find and defeat radar-controlled gun and missile sites. An expanding range of ECM and electronic intelligence gathering platforms including USAF F-100Fs and EB-66s and US Marine Corps EF-10Bs detected enemy radars such as "Fire Cans." Improved American ECM gradually reduced the SA-2 threat to the point where, in early 1967, 60 percent of the missiles fired around Hanoi lost their guidance signal or self-destructed. This placed

an increasing burden upon the AAA battalions, although the gunners from these units were criticized by their Soviet advisers and NVA generals for using barrage fire to scare off US aircraft, rather than targeting individual jets. Barrage fire was seen to waste large quantities of ammunition and wear out gun barrels too quickly.

Gunners also learned to take advantage of the frequent low cloud ceilings over North Vietnam. If the cloud-base was at about 7,000ft, their shells could be fused to catch aircraft at that altitude as they climbed and slowed to begin their attack dives from a height where pilots could still see their targets. They also learned to move their gun batteries into the entry or egress routes used by attack formations, before relocating again after a large strike to new sites where they could ambush a force from a different position and avoid retaliatory air attacks.

There could be no better testament to the A-4's toughness than the survival of this VA-195 A-4C and its pilot, Cdr Sam Chessman, the squadron CO in 1968. After severe damage from a SAM explosion that caused massive fuel leaks, his Skyhawk was led back to *Ticonderoga* by a tanker aircraft, refueling all the way. Although fire broke out in the rear fuselage as he neared the carrier, Chessman managed to make a safe landing and the fire was extinguished. Having survived this close shave, he would ultimately fly 306 combat missions in the Skyhawk. Here, one of Chessman's pilots takes a closer look at the damage inflicted on his CO's jet. (US Navy)

A-4 EXCELLENCE

During the Vietnam conflict the A-4 came into its own with very high serviceability approaching 95 percent, and with under 15 maintenance man-hours per flying hour. As its Douglas-built predecessor the A-1 Skyraider was retired from Essex-class carrier air groups in 1958, the piston-engined attack aircraft was replaced by additional Skyhawks. As a result, these air groups boasted three 14-aircraft A-4 squadrons each. The jet's reliability meant that most of the Skyhawks were available for each day's operations.

The A-4 repeatedly demonstrated its ability to absorb combat damage that would have brought down many other aircraft types. Although powerplant failure accounted for a number of losses, both the J65 and J52 engines frequently survived fatal damage long enough to take their pilots to safety in seemingly impossible circumstances. Around a third of US Navy flights into North Vietnam were by A-4s, yet the jet was second only to the A-1 Skyraider in terms of its wartime loss-to-damage ratio.

One example occurred during a November 23, 1966 *Iron Hand* mission by VA-192 in which the A-4E (BuNo 151172) of squadron CO Cdr Allen Hill was hit by AAA during a rocket attack on a petroleum/oil/lubricants storage site at Can Thon near Hon Gay. The Skyhawk began to burn, and although its engine produced only partial power it enabled Cdr Hill to fly for 40 miles and eject safely over the sea. Others made it home with crippling damage. VA-195's CO took a hit under the nose that prevented his A-4C's nose-gear from extending. He landed on his main landing gear, caught a wire with his tailhook and skidded to a halt. The aircraft was repaired and back in service 48 hours later.

Losses could be avoided for weeks and then run at three per day. On July 14, 1967 two VA-76 A-4Cs and an A-4E from VA-164 were downed by AAA and SAMs, and the latter unit suffered even worse luck four days later when three of its jets went down on a single mission. Another trio of losses occurred on August 31 when two A-4Es

For *Hancock*'s seventh war cruise from January to October 1972, CVW-21 included three A-4F squadrons. TIAS-equipped A-4F BuNo 154996 (foreground) is from VA-55, and the aircraft of VA-164 and VA-212 are preparing to join it for a May 25, 1972 mission over Vietnam. The carrier made one more war cruise in 1973 up to the cut-off date on August 15, when US action ended and the A-4 units concluded nine years of continuous combat in Southeast Asia. (US Navy)

from VA-163 and a Skyhawk from VA-164 were downed by two SA-2s. VA-192 deployed with 14 A-4Es as part of CVW-19 embarked in *Ticonderoga* in October 1966 and duly lost eight jets in combat during 126 days on the line. It had to trade in its shot-up Skyhawks for 14 new ones at the end of its fourth, and last, line period on April 28, 1967. Pilots were aware of the extreme randomness of being hit by any one of the thousands of rounds aimed in their general direction. Some survived 100 missions untouched while others were shot down more than once.

US Marine Corps A-4s flying predominantly CAS missions were most at risk from small arms fire. In 1968 it caused 16 of the 23 losses, with 12.7mm guns proving to be the most destructive weapons. In some cases, it was difficult to be certain that small arms had been involved as their gunfire could not be seen in daylight. Indeed, a number of pilots may have simply hit the ground during low-altitude attacks.

Some carrier air wings suffered heavy losses during several combat cruises while others were far more fortunate. The anti-submarine carrier USS *Shangri-La* (CVS-38), which was used for a solitary TF 77 cruise as an attack carrier, suffered only one combat loss during its 120 days on the line in 1970 – A-4C BuNo 148484 of VA-172 crashed in Laos on April 21, killing pilot Lt(jg) John Golz. The likely cause was target fixation during a night strike on the Ho Chi Minh trail. No AAA was seen by the other flight members. *Shangri-La* lost five more Skyhawks in operational accidents (three owing to catapult failures), with one pilot being killed. Loss rates obviously depended on the state of the war at the time and the numbers of A-4s in use.

In 1971 (another quiet period in the war) there was just one Skyhawk casualty – A-4F BuNo 154930 of VA-164 that crashed shortly after launching from *Hancock*. At that time the carrier's three A-4F squadrons were the only Skyhawks in-theater, as the US Marine Corps A-4 units had been reassigned to MCAS Iwakuni or sent back to airfields in the USA. Conversely, in the three-year period 1965–67, when US Navy and US Marine Corps A-4 losses totaled 238, the Skyhawk was present on virtually all the TF 77 carriers committed to the fighting. There were no fewer than 29 carrier-based light attack units equipped with A-4s during that period (with many of them being committed to combat for much of that time), as well as 12 US Marine Corps squadrons, three of them flying from carriers.

Hancock made a record number of eight TF 77 combat cruises up to 1973, losing 12 aircraft (eight of them to enemy action) on its seventh deployment in 1972 – by then the carrier's embarked air wing, CVW-21, was the only A-4 operator. Seven of the aircraft destroyed were Skyhawks. As noted in the previous chapter, the final A-4 lost in combat, however, was from VMA-211.

In 1971–72, as A-6s and A-7s took on the Skyhawk squadrons' duties, flak suppression became more urgent, and more difficult, as mobile 57mm guns appeared in increasing numbers throughout areas where air strikes were required. The first loss of an A-7A (BuNo 153239 of VA-147) on December 22, 1967 was caused by a SAM while pilot Lt Cdr Jim Hickerson was attacking a "Fire Can" AAA radar. F-4 Phantom IIs eventually became the main flak suppressors, offering speed, rapid acceleration and a heavy weapons load.

Total US Navy fixed-wing aircraft losses to AAA and small arms fire

1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	TOTAL
4	91	105	99	55	16	14	4	43	4	435

US Navy A-4 losses										
1	35	46	49	20	5	3	0	4	0	163

US Marine Corps A-4 losses										
0	1	9	14	19	13	7	0	3	0	66

Total aircraft losses (including helicopters) to all causes, both combat and operational – US Navy 878, US Marine Corps 700

A-4 wartime losses, to all causes										
1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	TOTAL
US Navy										
7	42	77	77	32	16	12	1	7	0	271
US Marine Corps										
1	5	14	23	27	9	8	0	4	0	91

Total A-4 losses by area (US Navy and US Marine Corps)				
South Vietnam	North Vietnam	southern Laos	northern Laos	other areas
84	185	22	1	15

AFTERMATH

AAA was undoubtedly the dominant factor in the wartime losses of US aircraft from all services. No less than 73 percent of USAF losses were thought to have been AAA-related, and in 87 percent of cases where the cause could be confirmed, AAA was to blame. Equivalent overall figures for the US Marine Corps were 64 percent and 97 percent, respectively.

Post-World War II analysis of anti-aircraft defenses concluded that 90 percent of bombers would get through even the most sophisticated artillery systems – an alarming prospect if any were carrying nuclear weapons. The major powers therefore turned to guided missiles as a solution, and they soon replaced the heavy AAA weapons within the inventories of both US and Soviet armies. The Vietnam War demonstrated conclusively that skillfully deployed guns could still be the decisive factor in severely reducing the effectiveness of aerial attacks.

By January 1991 missiles had replaced guns in many air defense networks. Although Coalition pilots in Operation *Desert Storm* still had to avoid prodigious AAA barrages when attacking targets in both Iraq and Kuwait, the majority of the 43 combat losses were to various ground-to-air missiles (including the Vietnam-era SA-2, which destroyed an F-14A+ TARPS Tomcat from VF-103) or mishaps such as premature ordnance detonation. However, the presence of AAA, including many of the weapons used by the North Vietnamese two decades earlier, remained a deterrent to low-altitude attackers. Furthermore, aircraft could still be brought down by a single lucky shot – an F-4G *Wild Weasel* was lost to fuel starvation after a single bullet penetrated a fuel tank.

The spirit of Ed Heinemann's design doctrine, emphasizing simplicity, small size and low cost, was reflected to some extent in the USAF's 1971 Lightweight Fighter program that led to the creation of the General Dynamics F-16 multirole aircraft.

A low radar signature that matched the A-4's was achieved thanks to the F-16's small profile, and this was subsequently exceeded in later designs by stealth technology, with inevitable high cost. Since then, the constant increase in the weight and complexity of avionics has led to substantially larger aircraft such as the F/A-18, F-22A and F-35 – the latter weighing up to three times as much as a fully loaded A-4. The need for lighter, cheaper force multipliers is currently leading to the development of small fighter and attack drones, managed by a larger aircraft or from the ground. They may well be able to handle some of the missions expected of the A-4 more than 60 years ago, but they will probably do so without a pilot.

In Vietnam the tough little Skyhawk and the pilots that flew it showed a remarkable resilience to the heaviest air defenses ever put in place up to that time. Although their aircraft carried a relatively small bombload compared with an F-4, A-4 pilots prided themselves on displaying greater accuracy than their Phantom II deck-mates. In the words of former US Navy MiG killer Cdr John Nicholls, "If one airplane kept us in the air over North Vietnam, it was the A-4."

VA-94's A-4Es were unusual in being nicknamed, like BuNo 152030 *JAUNTY JAN*, seen here with Mk 56 air-launched mines seconds away from being launched off the bow of *Bon Homme Richard* during the carrier's final combat cruise in 1970. *SWEET PAT* (411), *SASSY SUE* (also 411), *BOBBIE* (400), *JEANIE B* and *WAYWARD WIND* (412), *LITTER BUG* (405) and *SWEET MOL* were other named examples seen on this deployment, which was also VA-94's last with the Skyhawk. (US Navy)

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A-4 Skyhawk cover art
On February 7, 1965, Lt Edward A. Dickson of VA-155, embarked in USS *Coral Sea* (CVA-43), led a section of A-4Es in an attack on barracks and port facilities at Dong Hoi as part of Operation *Flaming Dart*. Twenty aircraft (both A-4Cs and A-4Es, as well as A-1H Skyraiders and escorting F-8D Crusaders) from *Coral Sea* were involved in the mission, which was the carrier's opening strike on its first of seven war cruises. As the attackers approached at 200ft above the flat coastal terrain Dickson's aircraft (BuNo 150075) was hit in the left wing by small-bore anti-aircraft fire as he prepared to drop his 500lb Snakeye bombs at 450 knots. He proceeded with the attack, but as he turned towards the sea 50ft flames streamed from his wing. Once over the water Dickson ejected, although his parachute failed to open and he was never found. He was posthumously awarded the Navy Cross. (Cover artwork by Gareth Hector)

North Vietnamese AAA cover art
The most common and usually the most successful type of anti-aircraft weapon used by the North Vietnamese was the Soviet M1939 (61-K) 37mm gun, a weapon with origins in the 1930s and an extensive record of action in World War II. Soviet forces had used it to great effect against Luftwaffe Ju 87 Stukas and medium-altitude attackers, its crews claiming almost 15,000 Axis aircraft shot down. During the long-running conflict in North Vietnam it became a basic anti-aircraft weapon. The M1939's eight-man crew fed shells manually into the breech, attempting a reload time of two seconds with five-round clips, while the gunner aimed it through an AZP-37 optical sight. When the weapon was used during the hours of daylight, effective camouflage was vital, and it could be towed to a new location at speeds of up to 60km/h within a few minutes of use. (Cover artwork by Gareth Hector)

Title Page
This ZPU-2 twin-mount 14.5mm machine gun is manned by two militiawomen. The gas-operated ZPU-2 was capable of firing 150 rounds per minute up to an altitude of more than 4,500ft. (Dr. István Toperczer Collection)